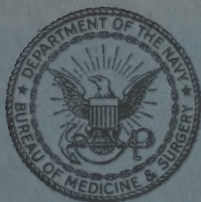


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# Mosquitoes of Okinawa and Islands in the Central Pacific



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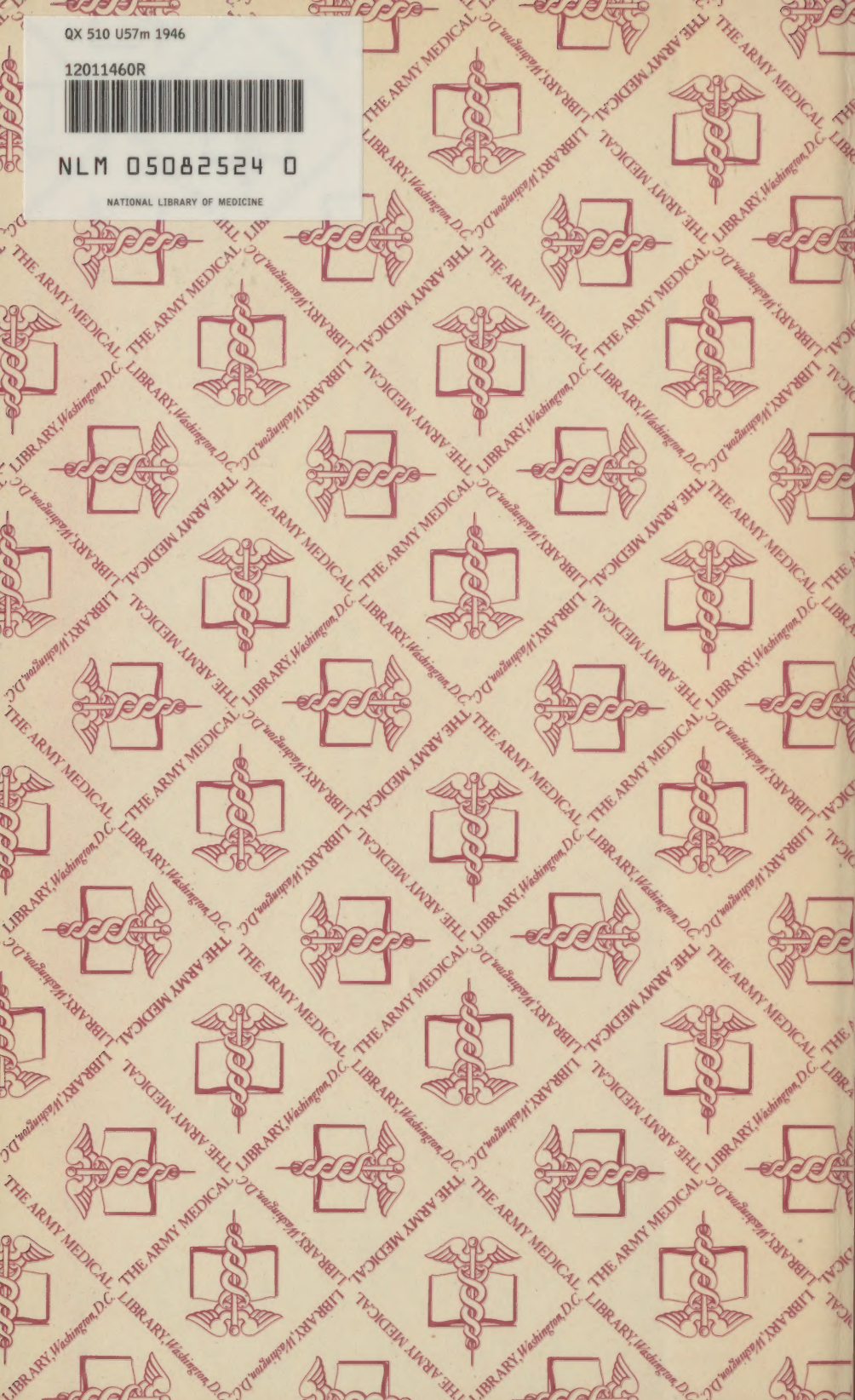
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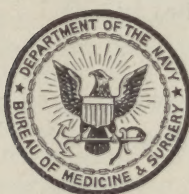
# Mosquitoes of Okinawa and Islands in the Central Pacific

By

RICHARD M. BOHART, LT. COMDR., H(S), U. S. N. R.

and

ROBERT L. INGRAM, CPhM, U. S. N.



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# MOSQUITOES OF OKINAWA AND ISLANDS IN THE CENTRAL PACIFIC

By

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and

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## GENERAL INTRODUCTION

Relatively little has been written about the mosquitoes of the far flung central Pacific Islands, and not until World War II has the importance of these insects as vectors of disease been fully realized. Even the less innocuous forms present interesting problems of biology and speciation. A great deal of work along widely different lines remains to be done before our information on central Pacific mosquitoes can be considered complete. For example, the dengue vector potentialities of *Aedes marshallensis* and *Aedes hensilli*, the two most common day-biting species respectively of the Marshall and Caroline Islands need to be studied. The importance of *Culex annulirostris*, a vicious night-biter in the Carolines, as a vector of nocturnal filariasis is unknown. The possibility that *Aedes pandani* and its relatives in the Marianas are vectors of dengue and filariasis is urgently in need of investigation. The role of the various Okinawan species in the transmission of Japanese "B" encephalitis is very imperfectly understood and this problem offers great possibilities to epidemiologists and entomologists. In addition to these and many other strictly medical questions there are a host of biological and taxonomic problems dealing with the effect of island isolation on the production of endemic species. Obvious points in need of study are the inter-relationships of the various members of the "*scutellaris*" complex and of the "*pandani*" group. Hybridizing experiments may yield information of broad application to the puzzling features of island speciation among insects.

In this paper we have tried to bring together and present in useful but condensed form the available information on the taxonomy, distribution, and bionomics of the mosquitoes on some central Pacific Island groups. The geographical scope of the paper is limited chiefly to Hawaii, Samoa, the Marshalls, the Carolines, the Marianas, Iwo, and Okinawa. Three principal island areas in the central Pacific belt have been excluded. Of these the Philippine Islands has been previously treated (Bohart, 1945) and other workers are now revising sections of its extensive fauna; Formosa is too little known to make its inclusion worthwhile; and the mosquitoes of Japan are being treated separately (Hsiao and Bohart, 1946).

Most of the areas considered in this paper have been visited by the authors as members of U. S. Naval Medical Research Unit No. 2, and collections were personally made in the Carolines (Truk), the Marianas (Guam and

<sup>1</sup> On Military leave from Division of Entomology, University of California.

Rota), and Okinawa. Extensive collections sent by other workers to the U. S. National Museum have also been available for study. We have included a total of 55 species and subspecies of which 27 appear to be endemic to certain islands or groups. This high rate of endemism reflects the effect of isolation upon development of species. Only 2 genera, *Aedes* and *Culex* are represented in the volcanic or coral islands of the mid-Pacific but 7 genera have been found on Okinawa, which is geologically more ancient and is closer to large land masses.

An explanation is needed for certain features of the style which we have adopted. Technical descriptions have been abbreviated as much as possible because most of them are supplemented by illustrations which show details far better than words. Drawings were made by the senior author and are based on camera lucida sketches. Technical descriptive terms are explained in figures 1 to 7. For simplicity, descriptions apply to only one side of the specimen concerned, unless otherwise indicated. Thus, only one antenna, pleuron, hind tarsus, and clypeal spine are described; and only one side of the body with respect to scutal markings, comb scales, pecten teeth, and siphon tufts. Only synonymy pertinent to the area under consideration has been given. Types of the new species have been deposited in the U. S. National Museum. Where sufficient paratypes are available, they will be sent to the Academy of Natural Sciences at Philadelphia, the California Academy of Sciences, the University of Sydney, and the British Museum.

Great strides have been made in recent years in the control of mosquitoes. The use of airplanes for distribution of DDT and oil is a recent innovation which is very successful in controlling larvae in relatively open areas. However, the control of larvae in artificial containers by this method does not appear to be satisfactory and a more laborious clean-up campaign must be used. In this paper methods on control are largely limited to our own personal observations.

This work has been made possible through the cooperation of the U. S. National Museum. An office was provided by Dr. W. Schmitt, Curator of Biology; and insect collections and other museum facilities were provided by Dr. E. A. Chapin, Curator of Insects. Dr. Alan Stone, Division of Insect Identification, U. S. Department of Agriculture and Plant Quarantine, was of inestimable help throughout the investigation; we have taken advantage many times of his extensive knowledge of mosquitoes. Material and technical advice was furnished by Dr. Kenneth L. Knight, Lt. Cmdr., H(S), USNR and J. Laffoon, PhMlc. Dr. T. Y. Hsiao gave helpful information, particularly with respect to Oriental literature sources. L. Isenhour, Y2c prepared the map of Okinawa, lettered the drawings, and typed the manuscript.

## TECHNIQUE

The following methods of handling mosquitoes were used by the authors in the Pacific area. However, they are not the only satisfactory ones, nor are they entirely original.

*Adult collecting.*—The equipment used was an aspirator, cyanide vials, small tins (C-ration cans), and a flashlight. The aspirator was of the straight variety made with 6 inches of large glass tubing and 18 inches of rubber tubing with a plug of gauze at the inner end of the glass tubing. The tins had the ends cut out and replaced with gauze secured by rubber bands. A hole was cut in the side of each can and covered with a cotton stopper. Adults resting in dark corners of houses, sheds, caves, on damp rocks and

vegetation, etc., were netted. After being withdrawn from the net with the aspirator and superficially examined, the adults were gently blown into the cyanide vial or into one of the tins through the cotton-plugged hole. In places such as rock crevices and tree hollows, where the net would be at a disadvantage, the aspirator alone was used. If the can containing live adults was kept cool and damp by wrapping it in damp cloth or leaves, the adults remained alive for several days.

*Oviposition.*—Gravid females brought alive into the laboratory were often induced to lay eggs. Each female was placed in a separate small shell vial fitted inside with a lining of filter paper reaching halfway up the vial and two-thirds around it. A small amount of water was placed in the bottom of the tube to keep the filter paper damp and the tube was stoppered with cotton soaked in a 10 percent sugar solution. When eggs were obtained, those not used for rearing were preserved in procaine tubes<sup>2</sup> containing 3 percent formalin and packed loosely with cotton to hold the eggs against the glass so that they could be studied without removing them from the tube.

*Preservation of adults.*—Most adult specimens which were not individually reared were placed in small tin or cardboard pillboxes. To discourage mold and insect pests a very small amount of powdered naphthalene was placed in the bottom of the pillboxes and covered with a thin layer of loose cotton. Successive layers of soft tissue paper carefully cut to fit the pillboxes were then added, with 10 to 20 adults between each layer. Adults captured in nature were put directly into the pillboxes from the cyanide vials. Reared material was transferred to empty bottles with the aspirator and allowed to harden for 24 hours. It was then killed and placed in pillboxes, or if it represented individually reared material, the adults were glued to stiff paper points with amyl acetate cement (thick and colorless fingernail polish), with a reference number and collection data. The same number was given to slide mounts of the associated larval and pupal skins. Both mounted and unmounted specimens were put in a drying cabinet which was constructed from a large box or crate fitted with an electric bulb or small kerosene lantern to raise the temperature to about 100° F. The bulb or lantern was placed at the bottom of the box so that the rising heat currents would dry the material on shelves above.

Male genitalia were removed from the specimen by snipping the last two segments of the abdomen with fine scissors.<sup>3</sup> The genitalia were placed in a simmering 10 percent solution of NaOH or KOH for 2 or 3 minutes. The "tail" was then removed with forceps or a small spatula to a rinse of water and then transferred to cellosolve<sup>4</sup> for about 10 minutes. The genitalia were then placed ventral side up in the mounting medium and a coverslip was carefully applied. In the genus *Culex* the styles were removed with fine needles to give a better view of the subapical lobe and its processes; in the subgenus *Culex* the mesosome in some specimens of each species was also dissected to show the lobes in flat view; the claspettes of *Finlaya* and the basal lobes of some *Stegomyia*, particularly the "*scutellaris*" group, were removed from representative specimens and mounted flat. The preferred mounting medium was euparal, with balsam a second choice. Fresh slides were not placed on edge for a week or so and balsam slides were heated in a drying cabinet for about 1 week until hardened. The euparal contracted

<sup>2</sup>Procaine tubes are extremely useful rubber-stoppered vials which can be obtained from dentists.

<sup>3</sup>Dried specimens should be first relaxed in a damp chamber.

<sup>4</sup>Ethylene glycol monomethyl ether.

considerably as it dried, particularly if a thin medium had been used, and additional material was added to the edge of the coverslip when necessary. In general a small coverslip was preferable to a large one, both to save mounting medium and to avoid crushing. Small square coverslips were prepared by cracking larger ones with a razor blade.

*Preservation of larvae.*—Mature larvae were transferred with a wide-mouthed pipette to a rinse of water one or more times to clean them, and in the final rinse the excess water was removed by a pipette. Clean water was heated almost to the boiling point in a test tube, agitated to remove the excess bubbles and poured over the larvae. About 30 seconds later the larvae were gently removed with forceps or spatula to procaine tubes containing 70 percent ethyl alcohol. A small cotton plug, freed of air, was inserted above the larvae to cushion them, and a data card (in pencil or india ink) was placed in the top of the vial.

Specimens to be mounted were killed in the same manner, placed in a dish of 70 percent alcohol, the thorax punctured ventrally with a dissecting needle, the abdomen partially torn in the region of segment VII to permit the "tail" to assume a lateral position when mounted, and transferred with forceps or spatula to cellosolve. They were left in cellosolve for at least 2 and not more than 24 hours and mounted in euparal. When balsam was used, overnight soaking in cellosolve was advisable. Two or more larvae were placed on a single slide where there was no doubt as to their identity. Larval and pupal skins were mounted directly after rinsing a few minutes in cellosolve. Associated skins were placed on a single slide with a number referring to the adult. Completed slides were handled as described above for genitalia.

## MOSQUITOES OF THE HAWAIIAN ISLANDS

Only three species of mosquitoes are known to occur in the islands, a fourth species, *Megarhinus inornatus*, having been introduced but apparently not established. *Aedes aegypti*, *Aedes albopictus* and *Culex quinquefasciatus*, all widespread species, are common in the islands as they are elsewhere in the world throughout most of their range. *C. quinquefasciatus* was introduced from Mexico in 1826, *aegypti* appeared prior to 1892 and *albopictus* was common by 1902 (Usinger, 1944). *C. quinquefasciatus* is the chief pest mosquito near human habitations and according to Usinger (1944) the larvae breed prolifically in street gutter catch basins, ground pools in air raid shelters, sugarcane field irrigation water, and brackish water wells. He reported it also at 5,000 feet elevation on the island of Hawaii. Although a notorious carrier of filariasis in other parts of the world, it is not known to carry this disease in Hawaii. *Aedes aegypti* and *albopictus* have been responsible for severe dengue epidemics in 1903, 1912, and 1943, with lesser outbreaks in 1913, 1914, and 1915. The dengue epidemic of 1943 is thought to have been started by infected commercial fliers from the South Pacific. A single case of yellow fever is known, contracted by a watchman who boarded a ship from Mexico in 1911. Absence of secondary cases is attributed to vigorous mosquito eradication and quarantine measures by health officers.

Control of Hawaiian mosquitoes, all of which breed commonly in artificial containers, is chiefly concerned with the clean up of premises. This slow and painstaking process will show excellent results with *aegypti* and will be partially successful with the other two species. The development of new

chemicals, such as DDT, should greatly improve the chances of mosquito eradication, at least in some areas. In the case of *albopictus*, however, which breeds in tree holes and water of leaf axils in the extensive lower forest zone, possibility of eradication appears extremely doubtful.

1. *Aedes (Stegomyia) albopictus* (Skuse)—Figure 17.

*Culex albopictus* (Skuse) 1894. Ind. Mus. Notes 3:20 (type locality: Calcutta, India).

*Female*.—Length of wing about 2.5 mm. Nape with a few upright black scales; vertex scales all broad appressed, a large median spot, eye margin, a sublateral spot, and a lateral spot silvery; torus and apex of palpus silvery scaled; proboscis black. Scutum with a median silvery stripe which becomes very narrow and forks posteriorly, a posterior submedian silvery lateral line and a few silvery scales over wing base; scutellum with broad appressed silvery scales only; prothorax and pleuron with patches of silvery scales; wing dark scaled; femora with prominent knee spots, a line beneath on fore and mid legs, hind femur with basal half white behind and two-thirds or more in front, the white area tapering narrowly to a point which nears the knee spot; tibiae dark except for some inner pale scales; fore and mid tarsi with pale marks at base of first two or three segments; hind tarsus with basal white marks occupying about two-sevenths of I, one-third of II, two-fifths of III, three-fifths of IV and all of V. Abdominal tergites with narrow and sometimes incomplete basal bands which widen into spots sublaterally, detached oblique lateral spots also present.

*Male*.—Palpus slightly longer than proboscis, segments with basal white marks. Ninth tergite with a backward projecting median knob (fig. 17); basal lobe of basistyle with slender setae of varying lengths.

*Larva* (description based on 10 specimens from Tinian and Saipan in the Marianas).—Antenna with a small hair at middle or slightly beyond; clypeal spine very slender; head hairs *C* and *B* usually single, *d* multiple. Shoulder hair 1 with 4 or 5 branches, 2 single, 3 and 7 double, 4 double or triple, 5 and 6 single; meso- and metathoracic pleural hairs with a weak basal spine. Comb of 8 to 10 strong teeth which are weakly fringed as far apically as basal one-fourth or one-third of shaft; fifth pentad hair with 2 to 4 branches, third pentad hair with 4 to 6 branches; siphon about 2.2 to 2.5 times its basal diameter, 8 to 11 pecten teeth on basal half of tube, followed at about middle by a triple or rarely quadruple hair; anal segment with a nearly complete sclerotized ring which is hardly spiculate along its posterior margin, and which bears a hair with 2 unequal branches; gills nearly equal, apically rounded, 2 or more times as long as anal ring.

*Biology*.—Larvae are most often found in artificial containers and tree holes, more rarely in cut bamboo, rock holes and leaf axils. In Hawaii they have been found in the axils of *Bilbergia*, *Crinum*, *Alocasia* and *Pandanus* as well as in more ordinary situations (Williams, 1944). The species is semidomestic and the breeding places are usually close to habitations or in places frequented by human beings. This generalization is not so obvious in the Hawaiian Islands, however, where *albopictus* occurs throughout much of the lower forest zone as well as in urban sections. The adults are severe pests in wooded areas where they rest under leaves and bite during the day. There have been occasional reports of night biting but this has not been observed by the authors.

*Distribution.*—Hawaii, Saipan, Tinian and generally distributed throughout the Oriental region. According to Bryan (1934) it is widespread in Hawaii.

*Systematics.*—The species has frequently been confused with members of the “*scutellaris*” group. The records of Esaki (1939) for the Caroline Islands (*Kusaie, Ponape, Truk*) are probably referable to *Aedes hensilli* of which we have specimens from Truk and the more western Carolines. Records from north Australia and Melanesia probably refer to *Aedes zonatipes* and related species. Members of the “*scutellaris*” group are characterized by their linear pleural scale markings. Those of *albopictus* are more definitely spotted. Male *albopictus* are readily separated from other known *Stegomyia* by the triangular projection of the ninth tergite (fig. 15). Related species in the *albopictus* group are *gurneyi* Stone and R. Bohart, *pseudalbopictus* Borel, *novalbopictus* Barraud, *subalbopictus* Barraud, *flavopictus* Yamada and *downsi*. In addition to differences in male genitalia, *subalbopictus* has the abdomen all dark above, *flavopictus* has some of the scutal markings yellow tinged, and *downsi* has the abdomen and legs differently marked (see description). A cross between *albopictus* and *aegypti* has been performed in the laboratory (see under *aegypti*).

*Relation to disease.*—Simmons et al (1930) in the Philippines were able to infect 100 percent of *albopictus* which had fed on infective cases of dengue 13 to 22 days previously. The role of this species as a dengue vector is now well established. There is some question as to the relative efficiency of transmission by *albopictus* and *aegypti*. However, this is probably governed by epidemiological factors. With respect to filariasis, Yamada (1927) and Hu (1935) were unable to obtain infective stage larvae of *W. bancrofti* in *albopictus*. Hu (1941) reported that the species was likewise not susceptible to experimental infection with *W. malayi*, confirming the findings of other workers. The species is not known to be involved in the transmission of Japanese “B” encephalitis.

## 2. *Aedes (Stegomyia) aegypti* (Linnaeus)—Figures 16, 65.

*Culex aegypti* Linnaeus 1762. Hasselquist's Reise nach Palestina p. 470  
(type locality: Egypt).

*Aedes argenteus* of authors.

*Stegomyia calopus* of authors.

*Stegomyia fasciata* of authors.

*Female.*—Length of wing about 2.5 mm. Nape with yellowish upright scales; vertex with broad appressed scales (except for a row of narrow curved silvery scales along eye margin) which are silvery in a median stripe, a sublateral and a lateral spot; ring on torus, two clypeal spots and apex of palpus silvery; proboscis dark. Scutum black with a silvery lyre-shaped pattern consisting essentially of a narrow submedian line and a lateral bowed line (fig. 16), a few pale scales over wing base; scutellum with silvery broad appressed scales and a few apical dark ones on mid lobe; prothorax and pleuron with patches of silvery broad appressed scales, ppn also with some pale narrow curved scales; wing dark scaled; femora with prominent knee spots, a broad complete pale line on hind surface of fore and mid femora and front surface of hind femur (sometimes broken), a narrow pale line interrupted subapically on front surface of fore and mid femora, hind femur mostly pale behind on basal three-fourths; tibiae mostly

dark: fore and mid tarsi with basal pale marks on first two or three segments; hind tarsus with basal white bands extending over about two-sevenths of I, one-third of II, one-half of III, three-fourths of IV and all of V. Abdominal tergites with pale basal bands which are usually complete in dorsal view, laterobasal spots also present, seventh tergite with two conspicuous small white spots, usually a few apical pale scales on some tergites.

*Male*.—Palpus slightly longer than proboscis, segments with basal white marks. Ninth tergite with posterior margin deeply concave, dististyle somewhat swollen toward middle (fig. 16).

*Larva* (description based on 10 specimens from Guam, Tinian and Saipan in the Marianas).—Antenna with a single hair usually inserted well beyond middle; clypeal spine very slender; head hairs *C* and *B* single and plumose. Shoulder hair 1 double to quadruple, 2 and 6 single, 3 double, 4 single or double, 5 and 7 double or triple; meso- and metathoracic pleural hairs with a heavy curved spine at the point of insertion. Comb of 6 to 10 teeth with several strong lateral denticles; fifth pentad hair with 2 to 5 branches, third pentad with 5 to 8 branches; siphon about 2.0 to 2.5 times its basal diameter; 9 to 17 pecten teeth on basal half of tube followed at about middle by a double to quadruple hair; anal segment with a nearly complete sclerotized ring which is hardly spiculate along its posterior margin, and which bears a hair usually consisting of 2 short equal branches; gills nearly equal, apically rounded, usually about twice as long as anal ring.

*Biology*.—This species is probably the most domestic known mosquito. The breeding places are never found far from human habitations and we have rarely found larvae more than a few feet from living quarters. Artificial containers are favored but occasional collections have been made in tree holes, coconut shells and cut bamboo. Larvae prefer rainwater but will live in chlorinated drinking water and slightly brackish well water. Partially shaded containers are ideal breeding places. *Ae. aegypti* larvae are often associated with *C. quinquefasciatus*, but not when the water is grossly polluted with food or sewage. The sinuous movement of many *Aedes* larvae is accentuated in *aegypti* and they are extremely shy. The adults bite mainly at night and they will feed readily on man, mouse, chicken, guinea pig, dog, and other warm-blooded animals. In the absence of the latter they will feed on frog or turtle (Woke, 1937). The theory has been advanced by several authors that the first blood meal after emergence is taken during the day and subsequent meals only at night. The adult female has a relatively long life. H. S. Hurlbut (1945) found 11 out of 50 specimens lived 42 to 54 days. Lewis (1933) reported a life range of 2.5 to 30.5 days under varying conditions. Edwards (1941) recorded a life for females of 22 to 116 days. The flight range is generally considered to be very short, and the discontinuous distribution on many Pacific Islands supports this view. However, Shannon and Davis (1930), working in Brazil, stated that a flight of about 1,000 feet is not exceptional. Eggs are laid on damp surfaces and can withstand dessication.

*Distribution*.—Widespread near habitations in tropical and subtropical climates. According to Bryan (1934), the species is widely distributed in Hawaii.

*Systematics*.—*Ae. aegypti* belongs to a group of African *Stegomyia* with similar scutal pattern and male genitalia. Its closest relatives in the Australasian region are the "*pandani*" group and *scutoscriptus*. Among other things it differs from both in having a double median scutal line and two spots of

white scales on the clypeus. The larvae have characteristic prominent basal spines on the meso- and metathoracic pleural hairs. Toumanoff (1937, 1939) working in Indochina successfully crossed the species with *albopictus*. Several generations of progeny of *albopictus* females and *aegypti* males resembled *albopictus*. Only a single specimen was obtained from the reciprocal cross and it resembled *aegypti*. Downs and Baker (1946) crossed laboratory cultured *aegypti* females and *albopictus* males. All progeny for several generations resembled *aegypti*. The reciprocal cross was unsuccessful.

*Relation to disease.*—This species has been incriminated in the transmission of several diseases, including yellow fever, dengue, equine encephalomyelitis, bird malaria, and filariasis of dogs. Yellow fever is not a disease of the Pacific or of the Orient although a few cases have been reported. Dengue is carried also by *albopictus* and one or both species are capable of causing epidemics. Kesler (1933) produced equine encephalomyelitis in guinea pigs and a horse through the agency of *aegypti* 6 days after an infective blood meal. The specimens remained infective for at least 12 days. Davis (1940) was able to transmit the disease from birds or mammals to other animals with *aegypti* as well as with other *Aedes*. He postulated that most species of *Aedes* would be potential vectors of the virus. *Ae. aegypti* is considered to be the primary vector of *Plasmodium gallinaceum* in chickens.

### 3. *Culex (Culex) quinquefasciatus* Say—Figure 51.

*Culex quinquefasciatus* Say 1823. Jour. Acad. Nat. Sci. Phil. 3:10 (type locality: North America).

*Culex fatigans* of authors.

*Female.*—Length of wing about 3.5 mm. Vertex with whitish narrow curved scales, a lateral patch of whitish broad appressed ones, yellow upright forked scales and some black ones; palpus pale tipped; proboscis with some pale scales scattered ventrally. Scutum uniformly light brown; scutellum with somewhat paler narrow curved scales; lobes of prothorax with scales similar to those of scutum; pleuron nearly unicolorous orange brown with four small patches of pale scales; wing dark scaled; femora pale beneath; tibiae and tarsi unicolorous. Abdominal tergites with basal creamy bands, some of which are usually evenly rounded, the bands usually detached from laterobasal creamy spots.

*Male.*—Palpus longer than proboscis by last segment, last two segments with many long hairs, all segments with some pale scales beneath, those on subapical segment forming a line, those on apical a basal spot. Abdominal bands less regular than in female, usually attached to lateral spots. Mesosome and paraproct of characteristic form (fig. 51).

*Larva.*—Antenna relatively stout, constricted and tufted at apical two-thirds, basal two-thirds of shaft spiculate; clypeal spine slender; head hair C with about 6 branches which hardly reach front of head, head hair B similar but with about 5 branches, hair d single; mentum with about 28 teeth. Shoulder hairs long and stout, 1, 2, 3, 5, 6 all single, 4 double or triple, 7 double. Comb of about 40 small apically fringed teeth in a patch; first to fifth pentad hairs with about 7, 1, 8, 1 and 5 branches respectively; siphon about 3.8 times its basal diameter, tapering from basal one-third to apex, with 4 pairs of tufts, subapical one usually most lateral, first 2 tufts many branched, last 2 tufts with 2 to 4 branches; pecten of about 9 teeth with

strong basal denticles; anal segment with a complete sclerotized ring which is minutely spiculate along posterior margin and which bears a single short hair; with about 12 anal hair brushes, all in barred area; gills nearly equal, about 1.5 times as long as ring; osc single, isc double.

*Biology.*—Larvae are found in a great variety of situations including artificial containers and ground pools. They seem to prefer water grossly polluted by food or sewage. They occur occasionally in slightly brackish well water and rarely in tree holes. The adults bite primarily at night, when they are persistent and annoying. In addition to man they feed on birds, mouse, rabbit, dog, etc. There is some evidence for the occurrence of biological strains based on feeding habits. H. S. Hurlbut (1945) on Guam found that *quinquefasciatus* fed readily on chickens but poorly on rabbit, mouse, and man. This confirms the work of other authors. However, Wanson and Nicolay (1937) suggest that if such races occur they are induced by laboratory conditions. Favorite resting places of adult *quinquefasciatus* are the darker corners of habitations but they can be found also under buildings, in caves, in air raid shelters, and in other dark, damp situations near living quarters.

*Distribution.*—A worldwide domestic mosquito in tropical and subtropical climates. In more temperate zones it is replaced by *C. pipiens* Linnaeus. It is widespread and common in Hawaii.

*Systematics.*—*C. quinquefasciatus* is the only *Culex* (*Culex*) within the scope of this paper which has all dark tarsi and proboscis. It is most closely related to *pipiens* which has slightly different female abdominal markings. The male genitalia of *pipiens* have the ventral cornu shorter and more slender, but intermediates exist. Larvae of *quinquefasciatus* have a shorter and more swollen siphon, on the average.

*Relation to disease.*—It is an important vector of nocturnal filariasis (*W. bancrofti*) and bird malaria. Bahr (1912) and Byrd et al. (1945) found it an unlikely but possible vector of nonperiodic filariasis. It has been suspected as a vector of Japanese "B" encephalitis. It is not known to carry human disease in Hawaii.

#### 4. *Megarhinus inornatus* Walker.

*Megarhinus inornatus* Walker 1865. Proc. Linn. Soc. 8: 102 (type locality: New Guinea).

This species has predaceous larvae and the adults do not bite. It was introduced into Hawaii from New Britain by C. E. Pemberton in 1929 (Bryan, 1934), but it apparently has not become established (Williams, 1944).

## MOSQUITOES OF SAMOA

The Samoan group consists of 3 principal islands, Tutuila, Savaii and Upolu, and a few smaller islands. Tutuila is governed by the United States and the other two by New Zealand. The mosquito fauna of the three islands appears to be rather homogeneous and includes eight species. Six of these are widespread but *samoanus* is known elsewhere only from Tonga and *pseudoscutellaris* is peculiar to a South Seas area from Fiji to the Society Islands.

The three main islands are volcanic in origin and are mountainous, with elevations as great as 6,000 feet on Savaii and 2,000 feet on Tutuila. Rain-fall is high and there is no definite dry season. Villages are located near sea level on small plains around the islands.

The existence of nonperiodic filariasis and the resultant chronic elephantiasis among natives on Samoa has been known for many decades. However, prior to World War II this disease was not generally thought to affect Caucasians. In support of this theory was the presence for about 20 years of an American Naval base on Tutuila without any recorded cases among military personnel. Wartime emergencies with the necessity of quartering large numbers of men in close proximity to native habitations soon altered the picture. After several months on the island considerable numbers of men began to show clinical symptoms of filariasis. The absence of known cases in prewar days can be explained by a combination of circumstances. The vector, *pseudoscutellaris*, is a day biter and a weak flier. The men lived under sanitary conditions on a naval base well removed from the sources of infection in native villages. As evidenced by the highly filarious native population, clinical symptoms are not frequent even among those repeatedly infected. Hence, by the laws of chance, the few personnel who were bitten by infective mosquitoes, such as corpsmen assigned to villages, did not happen to exhibit obvious symptoms. In any case the danger is now fully recognized. With adequate mosquito control and permanent quarters for military personnel, this disease should become a matter of medical history on Samoa at least as far as the white man is concerned.

Fundamental information on Samoan mosquitoes and their relation to disease transmission was recorded by O'Connor (1923). Buxton and Hopkins (1927) published an extensive treatise on mosquito research in Samoa, particularly on Upolu. Much of the known biology and distribution are attributable to them. Among recent workers were Byrd et al. (1945) who confirmed much of the earlier work and presented some additional information. Many of the Samoan specimens in the U. S. National Museum were collected by K. L. Knight, W. G. Reddick, E. E. Byrd and P. S. Rossitor.

# KEY TO THE SPECIES OF SAMOAN MOSQUITOES

## Adults

1. Scutum with well defined silvery lines on a dark background; tarsal segments with silvery basal bands ..... 2  
Scutum without well defined silvery lines on a dark background ..... 3
2. Scutal pattern lyre-shaped with narrow submedian lines and bowed lateral ones (fig. 16); pleuron with silvery spots ..... *Aedes aegypti* (p. 11)  
Scutal pattern essentially consisting of a single median stripe narrowed posteriorly; pleuron with a silvery linear arrangement ..... *Aedes pseudoscutellaris* (p. 12)
3. Wings and legs elaborately spotted ..... *Aedes samoanus* (p. 14)  
Wings dark scaled; legs not elaborately spotted ..... 4
4. Abdominal bands incomplete or at least some of them incised medially ..... 5  
Abdominal bands complete, not incised medially ..... 6
5. Abdominal tergites with incised bands, at least on some segments; proboscis with poorly defined pale ventral area; hind tarsus with weak basal bands ..... *Aedes vexans nocturnus* (p. 15)  
Abdominal tergites with basal pale lateral spots; proboscis with a median pale creamy band; hind tarsus with apical as well as basal pale marks ..... *Culex samoensis* (p. 17)
6. Tarsi and proboscis dark; dorsal abdominal bands rather evenly margined ..... *Culex quinquefasciatus* (p. 21)  
Tarsi and proboscis banded ..... 7
7. Pale bands on one or more of abdominal tergites III to VI produced in a point at middle; fore tibia with a row of small pale spots in front, associated with a row of bristles ..... *Culex annulirostris* (p. 17)  
Pale tergal bands of III to VI rather evenly margined; fore tibia with a row of bristles in front but these not associated with pale spots ..... *Culex sitiens* (p. 18)

## Larvae<sup>5</sup>

1. Siphon with a single pair of subventral tufts located in or near middle one-third of tube; antenna not constricted beyond insertion of antennal tuft ..... 2  
Siphon with several pairs of subventral tufts; antenna constricted beyond insertion of tuft ..... 5
2. Comb teeth in a single regular row ..... 3  
Comb teeth in an irregular row or a patch ..... 4
3. Comb teeth with large subbasal denticles (fig. 16); meso- and metathoracic pleural hairs with a strong curved basal spine ..... *Aedes aegypti* (p. 11)  
Comb teeth with a subbasal fringe (fig. 18); thoracic pleural hairs with weak basal spines ..... *Aedes pseudoscutellaris* (p. 12)
4. Pecten teeth fairly regularly spaced; thorax and abdomen with numerous stellate hairs; comb in a patch of many teeth ..... *Aedes samoanus* (p. 14)  
Pecten with one or more detached teeth apically; no stellate hairs; comb in a single or double irregular row ..... *Aedes vexans nocturnus* (p. 15)
5. Clypeal spine very stout; gills short and globular ..... *Culex sitiens* (p. 18)  
Clypeal spine slender; gills not globular ..... 6
6. Siphon about 6 times its basal diameter and bearing about 6 moderate tufts (6 pairs) beyond pecten ..... *Culex annulirostris* (p. 17)  
Siphon usually 3 to 4 times its basal diameter, usually with 4 moderate tufts (4 pairs), one of which is often out of line ..... *Culex quinquefasciatus* (p. 20)

### 1. *Aedes (Stegomyia) aegypti* (Linnaeus)—Figures 16, 65.

(For description and further data, see p. 6.)

**Biology.**—In Samoa, larvae have been recorded in coconut husks and shells, tin cans, a small open concrete drain, water butts, and once in the top of a cut bamboo (Buxton and Hopkins, 1927). They state that it was never found far from the houses of Europeans.

**Records.**—On Samoa it is recorded from Upolu (Apia) and Tutuila. On

<sup>5</sup>The larva of *Culex samoensis* is not known.

the former island it is known to have been present for more than 40 years (Buxton and Hopkins, 1927).

*Relation to disease.*—Byrd et al. (1945) on Samoa confirmed the work of Bahr (1912) on Fiji who found that microfilariae of *W. bancrofti* did not develop beyond the tenth day in this species.

**2. *Aedes (Stegomyia) pseudoscutellaris* (Theobald)**—Figure 18.

*Stegomyia pseudoscutellaris* Theobald 1910. Entomologist 43: 156 (type locality: Suva, Fiji).

*Aedes variegatus pseudoscutellaris* of Edwards 1926. Bul. Ent. Res. 17: 103.

*Aedes scutellaris pseudoscutellaris* of Knight, Bohart and Bohart 1944. Keys to the mosquitoes of the Australasian Region. Nat. Res. Council, Washington.

*Aedes pseudoscutellaris* of Farner and R. Bohart 1945. U. S. Naval Medical Bulletin 44: 41.

*Female.*—Length of wing 3.0 mm. Vertex with dark upright forked scales toward nape, otherwise with only broad appressed scales, a median silvery stripe extending between eyes, a sublateral and a lateral silvery spot; torus and apex of palpus marked with silvery scales; proboscis dark. Scutum with a median silvery stripe, very much narrowed and forking posteriorly, a faint and more yellowish submedian posterior line, a group of silvery scales over wing base connecting with a line across upper portion of pleuron which extends onto apn; pleuron with another line across upper part of sternopleuron and mesepimeron, two other spots on these sclerites and prominent coxal spots; scutellum with broad appressed scales, all silvery except for a group of black scales on apex of mid lobe; fore and mid femora with a posterior line of pale scales; hind femur with basal half pale on posterior side and a tapering line on anterior surface, not quite reaching knee spot, knee spots moderate on all femora; tibiae dark except for a few inner pale scales; fore and mid tarsi with basal white marks on I and II; hind tarsus with basal white marks covering about one-fourth of I, two-sevenths of II, one-half of III, three-fifths of IV and all of V; wing dark scaled. Abdominal tergites with laterobasal white spots on II to VII, the spots curved backward so as to appear subbasal in dorsal view, the spots rarely coalesced to form a band, but at least not on IV.

*Male.*—Palpus slightly shorter than proboscis, segments with basal white marks; proboscis sometimes with some pale scales beneath; abdominal segment VIII mostly white scaled above.

*Larva* (description based on 10 specimens from Tutuila and Upolu, Samoa).—Antenna with a small hair about at middle: clypeal spine very slender; head hairs *C* and *B* single, *d* multiple. Shoulder hair 1 triple or quadruple, 2 and 6 single. 3 double or triple, 4 and 5 single or double; meso- and metathoracic pleural hairs with a weak basal tooth. Comb of 9 to 13 moderate teeth with a prominent fringe usually reaching to middle of shaft on some teeth (requires high magnification); fifth pentad hair with 3 to 5 branches, third pentad with 4 to 6 branches; siphon about 2.2 to 2.5 times its basal diameter; 9 to 16 pecten teeth on basal half of tube, followed at about middle by a tuft of 3, 4, or rarely 5 branches; anal segment with a nearly complete sclerotized ring which is hardly spiculate along its posterior margin and which bears a hair with 2 unequal branches; gills unequal, longer pair nearly twice that of shorter and about twice as long as anal ring.

*Biology.*—The biology of this species has been treated extensively by

Buxton and Hopkins (1927). The following notes are taken largely from these authors. The larvae occur commonly in coconut shells and husks, cacao pods, tree holes, and artificial containers. They breed infrequently or locally in crab holes, holes in lava and cut bamboo. Larval habitats are usually small and contain water of high organic content. However, larvae have not been found in leaf axils. As in related species, the larvae feed mainly on the sides and bottom of their breeding places. The adult bites at all times of day, particularly on cloudy days and in deep shade. It does not bite at night. Byrd et al. (1945) on the basis of distribution of natural infection in the mosquitoes concluded that the species has a short flight range. The adult mosquitoes rest in low-growing vegetation, under houses and in other protected places close to the ground. Man is the preferred host but specimens have been observed to feed on a horse. The egg is black, oval, and shorter than that of *aegypti*, being hardly 3 times as long as thick. Eggs are laid during the day on damp surfaces above the water level. When dry coconut husks and shells were collected and soaked in a bucket, numerous larvae emerged within a day, indicating that eggs can withstand dessication.

*Distribution*.—Tuamotu Archipelago, Society Islands, Cook Islands, Tonga, Samoa. Tokelau Islands and Fiji. Records from the Marquesas and Ellice Islands have not been verified; those from Guam pertain to *guamensis*. Samoan records include all the islands except Rose Atoll.

*Systematics*.—This species belongs to the “*scutellaris*” group of which 14 species have been described. All of these have been recorded from the Australasian and eastern Oriental Region. They are characterized primarily by the linear arrangement of the pleural scales. In other respects they closely resemble the *albopictus* group. A general discussion of the group was given by Farner and Bohart (1945) and Stone and Farner (1945). *Ae. pseudoscutellaris* differs from others of the “*scutellaris*” group by the combination of its usually unbanded abdominal tergites, the white tipped hind tarsus, the entirely dark female proboscis and the dark segments III to V of the fore and mid tarsi. The male genitalia afford the most reliable points of difference, however. The basal lobe of the basistyle is largely covered with bristles, none of which appear as thickened setae (fig. 18). The larva has well developed gills and generally simple comb teeth. The latter differ from those of *zonatipes* in having the fringe extending halfway down the shaft in most teeth.

*Relation to disease*.—Bahr (1912) stated that this species was the carrier of nonperiodic filariasis in Fiji. He found that the larvae reached an infective stage in 10 to 21 days. From July to November the infective stage was reached in 21 days but in November and December, when the temperature was 5° higher, development to the infective stage occurred in 10 to 13 days. By using a strong light, he was able to get *pseudoscutellaris* to feed at night on a Solomon Islander with *W. bancrofti* showing marked nocturnal periodicity. All stages in the mosquitoes were exactly as observed in the nonperiodic variety, and the ingested filariae developed in the same way both with respect to number and rapidity. The importance of *pseudoscutellaris* in transmission of nonperiodic filariasis was verified on Samoa by Byrd et al. (1945). They found 655 of 6,634 specimens (9.9 per cent) were naturally infected in the field. Many of the naturally infected individuals carried double and triple infections; and more than 15 per cent of those infected carried infective stage larvae. In a laboratory experiment more than 80 per cent of female

mosquitoes which survived 14 days after feeding on an infective case of filariasis contained infective stage microfilariae.

3. *Aedes (Finlaya) samoanus* (Gruenberg)—Figure 30.

*Finlaya samoana* Gruenberg 1913. Ent. Rundschau 30:130.

*Finlaya kochi* of O'Conner 1923. Lond. School Trop. Med. Res. Mem. 4.

*Aedes kochi samoana* of Edwards 1926. Bul. Ent. Res. 17:105.

*Aedes kochi samoana* of Buxton and Hopkins 1927. Lond. School Trop. Med. Mem. 1:95.

*Aedes samoanus* of Stone and R. Bohart 1944. Proc. Ent. Soc. Wash. 46:212.

*Female*.—Length of wing 3 mm. Vertex with many dark and yellow up-right forked scales, median area with yellowish broad appressed and narrow curved scales, flanked by 2 alternating spots each of black and yellowish broad appressed scales, pale narrow scales along eye margin; palpus and proboscis narrowly pale tipped, proboscis also with a broad median pale band. Scutum brown scaled with an indefinite pattern of creamy scales; scutellum with broad appressed creamy scales on all lobes, broad appressed dark scales on apex of mid lobe and a few inconspicuous pale narrow curved scales; pronotal lobes with creamy broad appressed scales; ppn also with a few black ones across top; pleuron with patches of pale scales; integument of spiracular area and posterior angle of sternopleuron dark; wing strikingly spotted and with many broad pale and dark scales, costa with a small yellowish spot at extreme base, a similar subbasal spot, a long spot at basal one-third, a somewhat shorter one at apical one-third and a similar one near apex, other pale areas present on wing, particularly at forks of veins; femora and tibiae elaborately banded with yellowish and whitish scales, hind femur with about 6 bands; hind tibia with about 8 to 10 spots and bands; femora with prominent apical ventral tufts of long outstanding dark scales; fore and mid tarsi with median and apical pale bands on I, an apical spot on II, III and IV dark, V all pale; hind tarsus with a pale basal, median and apical band on I, apical two-fifths of II and III pale, IV dark and V all pale. Abdominal tergites banded and spotted with yellowish and whitish scales, bands essentially basal, spots submedian on apical half of tergites, segments VII and VIII compressed laterally and bearing tufts of outstanding black scales on apices of the sternites.

*Male*.—Palpus about as long as proboscis and with about six pale bands. Abdomen with yellow areas tending to be coalesced. Dististyle slender; basistyle with a tuft of scales and a slender, bent, specialized seta along inner margin (fig. 30), bladeliike portion of claspette broadly triangular and sharply pointed.

*Larva* (description based on 10 specimens collected on Samoa from taro axils).—Antenna without spicules, hair slender, single or double, inserted about at apical one-third; clypeal spine double or triple; head hair *A* posterior to *B* and *d*, with 4 to 6 branches; *B* double, *C* single, *d* double to quadruple; mentum with 19 to 21 stout teeth; mandible with anterior tooth hardly pigmented (fig. 30). Shoulder hairs 1, 3 and 5 stellate, 2 single, 4 and 7 single or double, 6 single to triple. Thorax and abdomen with many stellate hairs most of which are plumose and blunt or emarginate apically. Comb of about 70 apically fringed teeth in a patch; third pentad hair double or triple, first and fifth pentads stellate with 7 or 8 branches; siphon about 2.3 times its basal diameter and not or only slightly pilose, acus appearing

to be a detached pigmented oval, 7 to 11 very slender and minutely fringed pecten teeth on basal one-half of tube followed by a hair tuft of 3 or rarely 4 branches, valve hairs about as long as anal ring; anal ring about half complete, with a patch of long spicules on either side of a very long plumose hair of 3 or 4 nearly equal branches; gills unequal, longer pair longer than anal ring; osc single, isc with about 6 branches.

*Biology.*—Larvae are found most frequently in taro axils but also occur to some extent in *Pandanus* (O'Connor, 1923 and Knight, 1943), wild *Canna* and pineapple (O'Connor, 1923). The abundance of this mosquito is attested by the statement of Buxton and Hopkins (1927) that "it is scarcely possible to find a large specimen of any of these plants (taros) which does not harbour larvae of this mosquito." Byrd et al. (1945) captured over 100 adult specimens from native huts in 4 hours from 8 to 12 p.m. According to Buxton and Hopkins (1927), the larvae may crawl considerable distances over damp surfaces. However, these authors did not observe the larvae to jump half an inch or more as reported by O'Connor (1923). The females feed at night or rarely during the day. They are persistent and have an irritating bite. The eggs are laid in strings on the leaf base of taro just above the water level according to Buxton and Hopkins (1927).

*Distribution.*—Samoa (Savaii, Upolu, Tutuila) and Tonga (Buxton and Hopkins, 1927).

*Systematics.*—This is one of the members of the "*kochi*" group which ranges from Samoa to the Philippines and contains nearly two dozen species. Characters of described species are given by Stone and Bohart (1944). The adults of *kochi* (Doenitz) and *samoanus* are separated with difficulty except by the male genitalia in which the small specialized seta of the basistyle in *samoanus* is distinctive. The larva of *samoanus* has the siphon practically bare in contrast to the finely pilose condition in most other species of the group.

*Relation to disease.*—Although this species is second in abundance to *pseudoscutellaris*, it has not been proven to carry disease. Byrd et al. (1945) dissected 261 wild caught females, all of which were negative for microfilariae.

4. *Aedes (Aedimorphus) vexans nocturnus* (Theobald)—Figure 69.

*Culex nocturnus* Theobald 1903. Monograph Culicidae 3: 159 (type locality: Fiji).

*Aedes vexans* Meigen of authors.

*Female.*—Length of wing 3.5 mm. Vertex with abundant yellowish curved scales in broad median area, a few pale upright forked scales toward front of this area and many dark upright scales toward nape, a lateral spot of dull pale broad appressed scales; torus with an inner patch of dull pale scales; palpus white at tip; proboscis with a very broad but poorly delimited median pale scaled area beneath, sometimes a few pale scales above. Scutum with a dark brown integument covered with an indefinite pattern of bronzy brown, yellow and whitish scales; scutellum with pale narrow curved scales only; pleuron light brown, darker in spiracular area and on upper part of sternopleuron, with three large patches of dirty white scales (two on sternopleuron and one on mesepimeron) and a few other scales; wing dark scaled or with a few pale scales along costa and vein 1; all femora (especially mid femur) speckled with yellowish and dark scales, knee spots present; tibiae narrowly

pale at base and apex, otherwise mostly dark; first two or three segments of fore and mid tarsi with basal pale bands; hind tarsus with narrow basal pale bands on all segments. Abdominal tergites with basal creamy bands and large lateroventral spots, some of the bands more or less incised at middle, V sometimes and VI and VII usually with some apical yellowish scales.

*Male*.—Palpus longer than proboscis by about half of last segment, last two segments and apex of preceding segment enlarged and with dense long hair; palpal segments with basal pale marks. Genitalia with large bladeliike dististyle (usually evident on pinned specimens).

*Larva* (description based on 10 specimens from Samoa, Guam and Saipan).—Antenna covered with spicules, a hair of 4 or 5 branches at basal one-third or two-fifths of shaft, beyond which shaft is darkened; clypeal spine slender and curved; head hair *A* multiple, *B* single, *C* single to triple. *d* minute and with 3 to 5 branches; mentum with 27 to 31 teeth. Shoulder hairs 1, 2, 4 and 5 single, 3 and 6 single or double, 7 triple or quadruple. Comb of 8 to 11 strong and sharp teeth in an irregular double row; first and second pentad hairs on a plate, third pentad with 6 to 10 branches, fifth pentad with 5 to 9 branches; siphon about 3 times its basal diameter, with an acus, 11 to 18 simple or subbasally toothed pecten teeth of which distal one or more are more widely spaced; siphon hair at about apical one-third of tube and usually of 3 to 5 branches which considerably surpass last pecten tooth in length; anal ring nearly complete, minutely spiculate along posterior margin, anteroventral angle with an acus-like projection; lateral hair small and single; about 16 anal brushes of which last 2 or 3 are anterior to barred area; gills about equal, pointed, 1.2 to 2.0 times as long as anal ring; osc long and single, isc shorter and with about 8 branches.

*Biology*.—The larvae are found in temporary ground rain pools such as road ruts, roadside ditches and grassy depressions. It appears sporadically following rains when it may occur in enormous numbers. Buxton and Hopkins (1927) found it 6 times on Samoa, breeding in partly dried marshes, a pig wallow and a roadside ditch. They also record it on Tonga in a tree hole with *Aedes aegypti*. In New Hebrides the junior author collected it in 1943 associated with *Aedes funereus ornatus* Theobald and *Culex annulirostris*. Females bite both by day and by night but appear to be less persistent than *vexans* of eastern United States. H. S. Hurlbut (1945) fed specimens in the laboratory at Guam on mouse and man.

*Distribution*.—Widespread in Australasia with records from Samoa, Tonga, Fiji, New Hebrides, New Caledonia, Australia, New Guinea, Marshalls, Marianas, Netherlands Indies, and Philippines. Samoan records are from Upolu and Savaii Islands (Buxton and Hopkins, 1927), Tutuila (Knight, 1943) and the nearby islands of Niuafuu and Niuatobutabu (given as Nui and Niutao by Buxton and Hopkins, 1927).

*Systematics*.—The Pacific form of *vexans* has generally been treated as *vexans* Meigen. There appears to be some difference in habits, however, and larvae from the Australasian region and the Philippines differ consistently in the branching of the head hairs. Typical *vexans* larvae usually have hair *C* with 3 to 5 branches and *B* with 2 branches. The Australasian larvae usually have head hair *C* single or double and *B* single. Male genitalia of specimens from Guam, Philippines, Italy, Washington, D. C. and Montana all

appear identical. For this reason we have decided to consider the Australasian and Philippine form a subspecies under the available name of *nocturnus*.

*Relation to disease*.—Unknown.

### 5. *Culex (Culex) samoensis* (Theobald).

*Pseudotaeniorhynchus samoensis* Theobald 1914. Entomologist 47:36 (type locality: Apia, Samoa).

*Female*.<sup>6</sup>—Vertex with pale narrow curved scales and dark upright forked ones, a lateral spot of gray and dark broad appressed scales; palpus dark; proboscis with a median creamy band. Scutum covered with brown scales with traces of paler scaling behind the middle; scutellum paler than scutum, with narrow curved scales; pleuron with some whitish broad appressed scales; basal pale bands on first four tarsals of fore and mid legs; hind tarsus with basal bands on all segments and traces of pale scaling on apices of I to IV; wing dark scaled. Abdominal tergites with small laterobasal creamy spots which are more prominent on VI and VII.

*Male and Larva*.—Unknown.

*Biology*.—The species is known only from three adult female specimens, two of which were collected in a latrine.

*Distribution*.—The two females which Theobald described were collected at Apia, Samoa (K. Friedrichs) at some time prior to 1914. Another female in the British Museum bears the data "Samoa, May to August, 1921 (O'Connor)," (Edwards, 1924).

*Systematics*.—According to Edwards (1924), the species is related to the *bitaeniorhynchus* group.

### 6. *Culex (Culex) annulirostris* Skuse—(See figure 49.)

*Culex annulirostris* Skuse 1889. Proc. Linn. Soc. N. S. Wales (series 2) 3:1737 (type locality: Australia).

*Culex jepsoni* of Bahr 1912. Jour. Lond. Sch. Trop. Med. Supp. 1.

*Female*.—Length of wing 3.5 mm. Vertex covered with pale to brownish narrow curved scales, many dark and a few upright forked scales, a lateral spot of dull pale scales; palpus pale tipped; proboscis with a creamy band covering median one-fifth to two-sevenths; scutal integument dark brown covered with very small mixed bronzy to pale, narrow curved scales; scutellum with pale narrow curved scales only; pronotal lobes narrow scaled; pleuron pale brown, darker in spiracular area and between creamy patches of scales on sternopleuron, with other less distinct dark areas; wing dark scaled except for a row along hind margin of costa; femora conspicuously speckled with yellow and dark scales, especially on mid femur; tibiae mostly dark but with a line of pale scales beneath, front tibia with an often inconspicuous row of pale spots in front, associated with a row of bristles; tarsi with very narrow pale bands covering the joints, last joint often dark or nearly so. Abdominal tergites with basal creamy bands which are produced in the middle on III to VI or at least on one of these segments; bands occupying less than half of tergites, VII with some apical pale scales.

*Male*.—Palpus longer than proboscis by its last segment, with five pale bands, last band occupying apical one-third to two-fifths of last segment,

<sup>6</sup>Description condensed from the original of Theobald.

apical half of palpus with many long hairs. Abdominal banding slightly broader than in female. Mesosome distinctive (see figure 49).

*Larva.* (description based on 9 specimens from Truk I.)—Antenna constricted and tufted at apical two-fifths, part beyond tuft darkened, basal portion with many spicules; clypeal spine strong, dark and moderately long; head hair *A* with about 8 branches, *B* triple or quadruple, *C* with 3 to 6 branches, *D* single and very slender; mentum with 15 to 17 teeth. Shoulder hairs long and strong, surpassing front margin of head; hairs 1, 2, 3, 5 and 6 single, hair 4 double, hair 7 triple. Comb of 39 to 47 apically fringed teeth in a patch; third pentad with 7 to 11 branches, fifth pentad with 4 to 6 branches; siphon about 6 times its basal diameter, with 10 to 15 pecten teeth, each with about 6 lateral denticles, a row of 5 or 6 lateroventral tufts (on each side of siphon) of about 8 branches on apical two-thirds of tube, most distal tuft often small; anal segment completely ringed and with a lateral hair which is single to triple and shorter than anal ring; about 12 hair brushes in barred area; gills pointed or narrowly rounded and usually longer than anal ring; osc single, isc double to quadruple.

*Biology.*—Larvae occur commonly in ground pools and artificial containers. The species has occasionally been recorded from brackish water but this must be a rare occurrence. Buxton and Hopkins (1927) record several unusual breeding situations in the New Hebrides, such as a cavity in a felled log, hot springs and a brackish land-locked lagoon. They found it once in a coconut shell on Samoa. Buxton and Hopkins (1927) report the adults as savage biters at night in the New Hebrides but they were unable to find wild adults on Samoa. The junior author found the species very annoying and persistent in the early evening on Truk. In one case a few females attempted to feed in the shade during the day.

*Distribution.*—Queensland, New South Wales, Northern Territory, Samoa, Tonga, Ellice Island, Fiji, New Hebrides, Solomons, New Ireland, New Guinea, Carolines, Moluccas, Lesser Sundas, Sumatra, Celebes, Borneo, and Philippines. Samoan records are from Upolu and Tutuila.

*Systematics.*—This species is very close to *sitiens*. The spots on the front tibia of *annulirostris* are diagnostic but are not easily seen. Larvae are much more readily separated, differing both in gill shape and clypeal spines. A subspecies of *annulirostris* occurs in the Marianas and is discussed under that section.

*Relation to Disease.*—In an experiment by Byrd et al. (1945) on filariasis in Samoa, 25 *annulirostris* survived to the fifteenth day following an infective blood meal. None of these carried infective larvae when dissected. Some worms were observed on or before the seventh day in other specimens. Bahr (1912), working in Fiji, was not able to obtain infective filarial larvae in this species (misidentified as *jepsoni*).

#### 7. *Culex (Culex) sitiens* Wiedemann—Figure 48.

*Culex sitiens* Wiedemann 1828. Aussereur. Zweifl. Insec. 1:542 (type locality: Sumatra).

*Culex jepsoni* Theobald 1910. Entomologist 43:158.

*Female.*—Agreeing with description given for *annulirostris* except as follows: Front tibia without a row of pale spots in front associated with a row of bristles. Abdominal tergites with relatively narrow basal creamy

bands which may be convex or slightly irregular but are not produced into a point on III to VI.

*Male*.—Last palpal segment with less than apical one-third pale, and with distinctive genitalia (fig. 48).

*Larva* (description based on 9 specimens collected on Guam from brackish water).—Agreeing with the description of *annulirostris* (p. —) except as follows: Clypeal spine short and stout (fig. 48); head hair *A* with 8 to 10 branches, *B* with 3 to 6 branches, *C* with 5 to 8 branches; comb of about 25 to 45 teeth; fifth pentad hair with 3 to 4 branches; siphon 4.0 to 4.5 times its basal diameter with 4 or 5 lateroventral tufts of 3 to 6 branches, a smaller distal tuft and 1 or 2 lateral tufts. Lateral hair of anal segment usually single and longer than anal ring; gills short and globular.

*Biology*.—Larvae occur in small coastal collections of brackish water or occasionally of fresh water. The authors have collected larvae along the shores of various Pacific islands in coral crevices and boats containing brackish to highly saline water. Causey (1937) collected it twice in Siam from highly polluted water exposed to the sun. Buxton and Hopkins (1927) did not find this species on Samoa but record it from New Hebrides from partly brackish elevated coral rockholes containing dead leaves. Larvae of *Aedes zonatipes* were associated. According to U. S. National Museum collection records, Knight (1943) found it in company with *Aedes vigilax* Skuse in brackish water on New Caledonia. The authors found it with *Culex litoralis* in the Marianas. H. S. Hurlbut (1945) reared *sitiens* in the laboratory on Guam in 25 percent sea water and less successfully in fresh water. He found that it fed readily on chicken, mouse, rabbit, and man.

*Distribution*.—Coastal Australia, Wallis, Samoa, Fiji, New Caledonia, New Hebrides, Solomons, New Britain, New Ireland, New Guinea, Truk, Palau, Ulithi, and Marianas. It is also widespread in the Oriental Region. Its occurrence in India and Africa are questionable (see discussion below). Samoan specimens in the U. S. National Museum were collected at Tutuila in 1943 by E. E. Byrd.

*Systematics*.—This species has been involved in taxonomic confusion for some years. Wiedemann's original description of a Sumatran mosquito is very incomplete and was assigned dogmatically to the species by F. W. Edwards. Barraud (1934) figures the larval siphon from India as hardly twice its basal diameter. This is much stouter than any specimens we have seen from Australasia, Philippines, or Okinawa. On the basis of Barraud's figure and description, the Australasian form has been called *jepsoni* Theobald. However, Bonne-Wepster and Brug (1939) figure a larva, presumably from Java, with a rather long siphon. This is sufficiently close to the type locality of *sitiens* to make it appear likely that either Barraud's figure is in error or it represents a different species.

The adult of *sitiens* is similar to *annulirostris* (see discussion under that species) but the larva can be distinguished from all others by its stout clypeal spine, globular gills and completely ringed anal segment. In the related species, *C. litoralis*, the anal segment is partially ringed and the pecten teeth are stouter.

*Relation to Disease*.—The report of Bahr (1912) on experimental transmission of *W. bancrofti* with this species (given as *jepsoni*) has been shown by Buxton and Hopkins (1927) to refer to *annulirostris*.

**8. *Culex (Culex) quinquefasciatus* Say—Figure 51.**

(For description and further data, see p. —.)

*Biology.*—The following breeding places in Samoa are given by Buxton and Hopkins (1927): Tin cans, rainwater barrel, muddy pig wallow, hollow tops of coconut stumps exposed to sunlight, drinking water in a kitchen, open drains, once in a tree hole, and rarely in coconut shells and husks.

*Records.*—In Samoa it has been collected on all the main islands.

*Relation to Disease.*—Experiments on Samoa indicate that this species is possibly a minor factor in transmission of nonperiodic filariasis. Bahr (1912) found development of *W. bancrofti* beyond the seventh day only once. In this instance a larva was found in the proboscis on the nineteenth day. Byrd et al. (1945) found only 2 specimens naturally infected with larvae older than those recently ingested. In over 200 experimentally infected females, only one developed a single larva to the infected stage.

## MOSQUITOES OF THE MARSHALL ISLANDS

The Marshalls are a double chain of coral atolls, consisting of 32 islands and some 867 reefs scattered over about 800 square miles. They lie northeast of the Carolines and almost due north of the Solomons. The National Museum has a small amount of material from the Gilbert Islands, which are just southeast of the Marshalls, and we have included these records.

None of the islands rise more than a few feet above sea level. They are covered with sand and have a scanty supply of soil. Consequently there is not a great variety of vegetation. Little is grown except taro, but the uncultivated coconut and *Pandanus* grow prolifically. The temperature varies little throughout the year, the range being 72° to 92° F. Knoll (1941) gives the rainfall for Jaluit as 5 to 21 inches a month.

Dengue was reported from the Marshalls as early as 1906. Filariasis is also known from these islands, presumably the nocturnal variety.

The material in the National Museum was collected by D. A. Treat, D. G. Hall, and B. Freeman. A total of four species is known, representing two genera, *Aedes* and *Culex*. Of these, *Aedes marshallensis*, which occurs in the Marshalls and Gilberts, is the only endemic form.

### 1. *Aedes (Stegomyia) marshallensis* Stone and R. Bohart—Figure 19.

*Aedes marshallensis* Stone and R. Bohart 1944. Proc. Ent. Soc. Wash. 46: 218  
(type locality: Airok Island, Ailinglaplap Atoll, Marshalls).

*Female*.—Agreeing with the descriptions of *pseudoscutellaris* (p. —) except for markings of hind tarsus and abdomen. Hind tarsus with basal white bands covering about one-seventh of I, one-fifth to one-sixth of II, one-fourth of III and IV, one-third to one-half of V. Abdominal tergites with basal lateral (ventral) white spots which are continued onto dorsum as subbasal complete or incomplete bands, usually complete or almost so on IV to VII.

*Male*.—Palpal segments with basal white marks; abdominal tergite VIII mostly pale; genitalia with peculiarly shaped basal lobe of dististyle (fig. 19).

*Larva* (description based on 6 specimens from Namorik Atoll, Marshall Islands, and 3 specimens from Abemama, Gilbert Islands).—Antenna with a single hair inserted about at middle; clypeal spine very slender; head hairs *C* and *B* single or rarely double, *d* plumose. Shoulder hair 1 double or triple, 2 single, 3 and 7 double, 4 single or double, 5 and 6 single; meso- and metathoracic pleural hairs with inconspicuous basal spines. Comb of 6 to 11 teeth which are heavily fringed, fringe reaching nearly to tip of shaft on many teeth, about 46 per cent of comb teeth with the shaft apically double or multiple; fifth pentad hair with 3 to 5 branches, third pentad with 4 to 7 branches; siphon about 2.0 to 2.5 times its basal diameter, 6 to 11 pecten teeth on basal half of tube followed at about middle by a hair with 2 to 4 (rarely 5) branches; anal segment with an incomplete sclerotized ring (less complete than in *aegypti* or *pseudoscutellaris*) which is hardly spiculate along its posterior margin, and which

bears a strong unequal 2 branched bristle; gills about equal, apically rounded, and 2 to 3 times as long as anal ring.

*Biology*.—Larvae occur in coconut half shells, tree holes, and hollows at the base of coconut fronds. The species has also been taken by B. Freeman from a well in the Gilbert Islands. Adults bite freely during the day. Collections of adults were made by D. A. Treat (1944) in the woods, within as well as beyond villages, and resting on the walls of a cool damp air raid shelter.

*Distribution*.—Marshalls: Airok Island, Ailinglaplap Atoll; Ebon Island, Ebon Atoll; Namorik Island, Namorik Atoll (D. A. Treat); Kili Island, Ennyebagan, and Berlin Islands, Kwajalein Atoll (D. G. Hall). Gilberts: Bairiki Island, Tarawa Atoll (J. L. Knott); Abemama Island (B. Freeman).

*Systematics*.—This species has been compared with others of the "*scutellaris*" group by Farner and Bohart (1945) and by Stone and Farner (1945). The adult most closely resembles *hensilli* but the hind tarsus has the white markings more reduced on IV and V. The male genitalia is unique in the basal lobe of the basistyle (fig. 19). The larva usually has the comb teeth heavily fringed and often divided. The only other species similar in this respect is *riversi*.

*Relation to Disease*.—Unknown. The related *pseudoscutellaris* carries non-periodic filariasis and *zonatipes* is thought to be involved in dengue transmission.

**2. *Aedes (Stegomyia) aegypti* (Linnaeus)**—Figures 16 and 65.

(For description and further data, see p. —.)

*Biology*.—Larvae were collected by D. A. Treat (1944) in rainwater cisterns and once in a coconut half on the edge of the woods. Adults were collected in native houses, most commonly at sunrise and sunset.

*Records*.—Marshalls: Ailinglaplap Atoll (Airok I.), Kili Island, Ebon Atoll (Ebon I.), Namorik Atoll (Namorik I.).

**3. *Aedes (Aedimorphus) vexans nocturnus* (Theobald)**—Figure 69.

(For description and further data, see p. —.)

*Records*.—Adults were collected in edge of woods at dawn on Ebon Island, Ebon Atoll (D. A. Treat).

**4. *Culex (Culex) quinquefasciatus* Say**—Figure 51.

(For description and further data, see p. —.)

*Biology*.—Larvae were collected by D. A. Treat (1944) in rainwater cisterns, a coconut shell, and in a well. Adults were collected in villages where they were biting at night.

*Records*.—Ebon Island, Ebon Atoll; Namorik Island, Namorik Atoll (D. A. Treat).

## MOSQUITOES OF THE CAROLINE ISLANDS

The Carolines are a widespread group stretching across the Pacific from east to west over 2,000 miles. There are well over 500 islands in the group but the principal islands or atolls are Ponape, Kusaie, Truk, Palau, Yap, and Ulithi. The islands range from large volcanic territories with mountains and streams to small flat coral islets only a few feet above sea level. There is very little variation in temperature throughout the hours of the day and months of the year, the range being from 72° to 89° F. The rainfall is fairly constant, that on Truk varying from 5 to 14 inches a month. Most of the other islands have a slightly higher rainfall, but there does not appear to be much seasonal variation. The larger islands, which are volcanic in origin, are forested and well watered. The principal trees are coconut, breadfruit, banyan, and mangrove. There are no large animals native to the islands; however, pigs, goats, and cattle have been introduced.

The National Museum has material of 14 species of mosquitoes from Truk, Palau and Ulithi. The Palau material is being studied by other workers and for that reason we are giving it only a synoptic treatment.

The Truk group consists of about 70 islands lying in a lagoon which has a radius of about 30 miles and is enclosed by a coral reef. The group is west of Ponape and north of the Mortlock (Momoi) group. The principal islands are Moen, Dublon, Tol, Udot, Fefan, Fala, and Uman.

The Palau group contains about 200 islands which comprise the western end of the Caroline chain. Babelthuap, the principal island, is about 20 miles long by 5 miles wide. It is the second largest in the Carolines, being surpassed only by Ponape. Pelileu and Angaur are small islands south of Babelthuap.

Ulithi Atoll lies northeast of Yap and consists of small islands which rise only a few feet above sea level. The main island is Mokomok.

Dengue is the principal insect-borne disease in the Carolines. Many cases have been reported by the Japanese. It was not mentioned in early German reports, but it is believed to have been present and recorded under some other name, such as grippe. Esaki (1939) suggested that dengue was a recent introduction from the Ryukyus, but earlier reports make this seem unlikely. There appears to be a tendency toward seasonal occurrence of the disease according to Sogen (1941).

Filariasis has been reported from most of the islands. Due to the frequent native migrations it is difficult to determine which cases are endemic and which are imported. Also, it is not definitely known whether the filariasis is periodic or nonperiodic, or both. If it was established by immigrants from the Samoan area it would be of the nonperiodic variety but if it was introduced by the numerous immigrants from the Ryukyus it would be of the nocturnal type, the latter being the more likely possibility.

All of the known Caroline species are in *Aedes* or *Culex*. Nine of them appear to be endemic, thus reflecting the geographic isolation of the islands.

The principal collectors following American occupation were G. Hensill and R. H. Baker (Ulithi); C. K. Dorsey, G. Starkey, J. Webb (Palau);

and R. L. Ingram (Truk). T. Esaki made collections on many of the islands before the war but very little pertinent data were published in regard to mosquitoes. Of interest is his record of an *albopictus*-like species breeding in pitcher plants on Babelthuap and Korrer (Esaki, 1939).

## KEY TO THE SPECIES OF CAROLINE MOSQUITOES

### Adults

1. Scutum with a pale median or submedian longitudinal line on a dark background ..... 2  
    Scutum without a pale median or submedian longitudinal line..... 6
2. Scutum with a lateral line bending inward at scutal angle; scales on pleuron in patches rather than in 2 more or less parallel lines ..... 3  
    Scutum without a lateral line bending inward at scutal angle; scales on pleuron arranged in 2 parallel lines, the upper one extending over wing base nearly to scutellum ("*scutellaris*" group)..... 4
3. Scutum with 2 submedian longitudinal pale lines; abdominal tergites III-VI with basal bands; fourth hind tarsal white at least on basal half, usually three-fourths ..... *Aedes aegypti* (p. 27)  
    Scutum with a single distinct median line, extending nearly to scutellum; abdominal tergites III-VI with subbasal lateral markings not forming complete bands; fourth hind tarsal almost entirely dark ..... *Aedes scutscriptus* (p. 27)
4. Hind femur without a tapered white line on anterior surface; hind tarsal segments IV and V interrupted by an inner dark line, that on IV broad, that on V consisting of a single or double row of scales..... *Aedes* sp. in *scutellaris* group (p. 27)  
    Hind femur with tapered white line on anterior surface; hind tarsal segments IV and V with complete white bands ..... 5
5. Hind tarsal IV with basal white band not occupying more than two-thirds of segment, hind tarsal V often apically dark; basal lobe of basistyle with specialized setae in a row (fig. 21)..... *Aedes hensilli* (p. 25)  
    Hind tarsal IV with basal white band occupying about four-fifths of segment, hind tarsal V all white; basal lobe of basistyle with specialized setae in a group (Fig. 20)..... *Aedes zonatipes* (p. 26)
6. Highly ornamented species; scutellar scales broad and appressed; sternite VIII of female large and prominent ..... 7  
    Species without evident ornamentation; sternite VIII of female small ..... 8
7. Legs with many yellow and dark stripes; wing with broad yellow and dark scales; proboscis with a median and an apical yellow band; scutum without a pair of anterior silvery spots ..... *Aedes (Finlaya)* sp. in *kochi* group (p. 29)  
    Legs uniformly dark except for hind surface of femora; wing with dark slender scales only; proboscis dark; scutum with a pair of anterior silvery spots. .... *Aedes (Finlaya)* sp. in *niveus* group (p. 29)
8. Vertex with mostly broad appressed scales; postspiracular bristles present ..... 9  
    Vertex with mostly narrow curved and upright forked scales; postspiracular bristles absent ..... 10
9. Abdominal tergites II to V with subbasal white bands; scutellar scales narrow ..... *Aedes (Aedes)* sp. (p. 29)  
    Abdominal tergites II to V entirely dark or a few segments with a basal lateral spot; scutellar scales broad..... *Aedes (Skusea) lamelliferus* (p. 29)
10. Proboscis with a pale band; mid femur speckled in front; tarsi with pale bands ..... 11  
    Proboscis unbanded; mid femur not speckled in front; tarsi not banded ..... 12
11. Fore tibia with a row of spots in front, associated with a row of bristles; abdominal bands angularly produced on some segments..... *Culex annulirostris* (p. 32)  
    Fore tibia without a row of spots in front; abdominal bands evenly margined ..... *Culex sitiens* (p. 32)
12. Abdominal tergites without basal bands, usually a basal lateral spot on at least VI and VII; antenna of male with specialized setae on several segments; scales on pleuron inconspicuous or apparently absent..... *Culex carolinensis* (p. 30)

Abdominal tergites with basal bands; antenna of male without specialized setae .....	13
13. Pleuron with large patches of white scales, but no definite markings. ....	
..... <i>Culex quinquefasciatus</i> (p. 32)	
Pleuron without scales but with a velvety dark brown spot on mesepimeron. ....	
..... <i>Culex pullus</i> (p. 31)	

#### Larvae

1. Siphon with 2 or more pairs of subventral tufts (usually 4 or more), siphon more than 3.5 times its basal diameter .....	2
Siphon with 1 pair of subventral tufts, siphon less than 3.5 times its basal diameter .....	6
2. Siphon with 5 or more pairs of tufts.....	3
Siphon with not more than 4 pairs of tufts .....	4
3. Siphon tufts nearly in a straight line; gills slender, not globular; clypeal spine slender .....	
..... <i>Culex annulirostris</i> (p. 32)	
One or 2 pairs of siphon tufts smaller and more lateral than other tufts; gills globular; clypeal spine stout.....	
..... <i>Culex sitiens</i> (p. 32)	
4. Siphon with a break in sclerotization near middle, not more than 3 pairs of siphon tufts, siphon at least 9 times as long as its basal diameter.....	
..... <i>Culex pullus</i> (p. 31)	
Siphon without a break in sclerotization, 4 pairs of siphon tufts; siphon not more than 5 times as long as its basal diameter.....	5
5. Apical half of siphon parallel-sided; clypeal spine dark, stout and cylindrical .....	
..... <i>Culex carolinensis</i> (p. 30)	
Apical half of siphon tapered; clypeal spine pale, fine; siphon usually swollen beyond base .....	
..... <i>Culex quinquefasciatus</i> (p. 32)	
6. Head hair B with 3 or more branches; anal ring with strong spiculation .....	7
Head hair B single or double; anal ring without definite spiculation .....	8
7. Antennal hair arising at about the middle, with 5 or 6 strong branches; body not densely covered with stellate hairs; comb in a row on a plate except for the first and last teeth <i>Aedes (Finlaya)</i> sp. in <i>niveus</i> group (p. 29)	
Antennal hair arising at about apical one-third, single; comb in a patch; body densely covered with stellate hairs .....	
..... <i>Aedes (Finlaya)</i> sp. in <i>kochi</i> group (p. 29)	
8. Siphon tuft of a single bristle; comb teeth in a patch; pecten teeth extending beyond sclerotization basally .....	
..... <i>Aedes lamelliferus</i> (p. 29)	
Siphon tuft with 2 or more branches; comb in a row; pecten teeth not extending beyond sclerotization basally .....	9
9. Metathoracic pleural hair with a large basal spine; lateral hair of anal segment with 2 equal branches, not longer than width of anal segment. ....	
..... <i>Aedes aegypti</i> (p. 27)	
Metathoracic pleural hair without a large basal spine; lateral hair of anal segment longer than width of anal segment .....	10
10. Pecten teeth in a curved line; head hair B usually with 2 branches; lateral hair of anal segment with 2 long, equal branches.....	
..... <i>Aedes scutoscriptus</i> (p. 27)	
Pecten teeth in a straight line; head hair B usually single.....	11
11. Siphon with 5 or 6 widely separated pecten teeth.....	
..... <i>Aedes (Stegomyia)</i> sp. in <i>scutellaris</i> group (p. 27)	
Siphon with 7 to 17 closely spaced pecten teeth.....	
..... <i>Aedes zonatipes</i> (p. 26)	
..... <i>Aedes hensilli</i> (p. 25)	

#### 1. *Aedes (Stegomyia) hensilli* Farner—Figure 21.

*Aedes hensilli* Farner 1945. Proc. Biol. Soc. Wash. 58: 59 (type locality: Ulithi Atoll).

*Female*.—Agreeing with description of *pseudoscutellaris* (p. 12) except as follows: Palpus all white above on terminal segment and apex of sub-terminal one, hind tarsus with variable markings as shown in figure 21. Abdomen with laterobasal white marks which are sometimes continued subbasally onto dorsum forming complete subbasal bands from III-VII.

*Male*.—Palpus slightly shorter than proboscis, with two white bands on long segment and white basal marks on last two segments; abdominal tergites III to VI usually banded, VII with a basal sublateral spot, VIII all white above. Genitalia as in figure 21.

*Larva* (description based on 7 specimens from Truk collected in artificial containers, and 4 topotype specimens from Ulithi Atoll).—Agreeing with the description of *pseudoscutellaris* (p. 12) except as follows: Shoulder hairs 1 and 4 double or triple, hair 5 single. Comb teeth with a fringe usually reaching about middle of shaft; third pentad hair with 3 to 6 branches, fifth pentad with 4 to 5 branches; 7 to 14 pecten teeth followed by a double or triple tuft; lateral hair of anal ring with 2 (rarely 3) unequal branches; gills unequal, longer pair about 1.25 times shorter pair, and 2 times as long as anal ring.

*Biology*.—According to Farner (1945) larvae on Ulithi were found in empty coconut shells, tree holes, and to some extent in artificial containers such as tin cans, discarded drums, barrels, and bottles used by the natives. On Truk, in addition to these situations, larvae were found in rock crevices and in fallen coconut fronds. Adults are active primarily at dusk (Farner, 1945). On Truk they were observed to attack man in the open or inside houses during the day. This species was observed resting among the aerial roots of a large banyan tree in an open field.

*Distribution*.—Ulithi Atoll (G. Hensill and R. Baker); Palau Group: Peleliu and Garakayo Islands (K. Dorsey); Truk Atoll: Moen, Udot, Tol, Uman, and Fala Islands (R. L. Ingram).

*Systematics*.—This species is similar externally to *marshallensis* but the fourth hind tarsal is more than one-third white. In specimens of *hensilli* from Ulithi the last hind tarsal is usually about half white, whereas in Truk specimens it varies from two-thirds white to all white. Of 35 males examined, 17 were all white; and of 42 females, 27 were all white. There is also a greater tendency for complete abdominal bands in the female among Truk specimens. Of 42 females, 34 had complete bands at least on V to VII and 9 of these had complete bands on III to VII. Of 9 females from Ulithi only 2 had complete bands on V to VII. Specimens with all white last hind tarsal are separated with difficulty from *zonatipes* except with respect to male genitalia. However, *zonatipes* has the fourth hind tarsal more than two-thirds white. The genitalia of *hensilli* are very similar to those of *riversi* and *guamensis*. The hind tarsi and the larvae are different in the 3 species, however.

*Relation to Disease*.—Unknown. It is a possible vector of filariasis and dengue.

## 2. *Aedes (Stegomyia) zonatipes* (Walker)—Figure 20.

*Culex zonatipes* Walker 1861. Proc. Linn. Soc. Lond. 5: 229 (type locality: Dorey, New Guinea).

*Aedes scutellaris hebrideus* Edwards 1926. Bul. Ent. Res. 17: 102 (type locality: Espiritu Santo, New Hebrides).

*Female*. Agreeing with description of *pseudoscutellaris* (p. 12) except as follows: Abdominal tergites II and III with incomplete subbasal bands, IV to VII with complete bands.

*Male*.—Abdominal bands similar to female except that VII has a sub-

median spot and VIII is white above. Genitalia as in figure 20. Specialized setae in a clump at dorsoapical angle.

*Larva.* Agreeing in general with the description of *pseudoscutellaris* except as follows: Comb teeth with fringe not usually extended more than one-third the length of the shaft; siphon tuft triple (in Pulo Anna specimens); anal gills nearly equal, longer pair about twice as long as anal ring.

*Biology.*—Larvae occur in coconut shells, tree holes and artificial containers. Caroline larvae (from Pulo Anna) were collected in an artificial container.

*Distribution.*—New Hebrides, Northern Australia, New Guinea, Ceram, Palau Islands, and the Philippines. Caroline records are from Pulo Anna and Angaur, Palau Islands (C. K. Dorsey).

*Systematics.*—According to Stone and Farner (1945), *zonatipes* (as *hebrideus*) closely resembles *pseudoscutellaris* except in the more complete abdominal banding of the former. The most diagnostic characters are in the male genitalia (fig. 20). The larva resembles that of *albopictus* closely and where the ranges of the two species overlap, as in the Philippines, identification should be based on rearings.

*Relation to Disease.*—This species has been implicated as a vector of dengue on epidemiological evidence (Daggy, 1944) and the experimental transmission work of Australian investigators.

### 3. *Aedes (Stegomyia) sp. in scutellaris group.*

*Biology.* Specimens in the National Museum have the following data: Larvae were collected from tin cans and coconut shells on Garakayo Island and from a tin can on Peleliu.

*Distribution.*—Palau Group: Peleliu and Garakayo Islands (C. K. Dorsey).

### 4. *Aedes (Stegomyia) aegypti* (Linnaeus)—Figures 16, 65.

(For description and further notes, see p. 6.)

*Biology.* On Truk (Moen I.) larvae were found by the junior author in metal drums used by Japanese troops. However, along the northern coast which was inhabited almost solely by natives, no larvae of this species were found. Several collections were made from suitable breeding places on other islands without turning up *aegypti*.

*Records.*—Truk Atoll: Moen I. (R. L. Ingram); Kusaie (Esaki, 1939).

*Relation to Disease.* There have been several large epidemics of dengue on Truk, Ponape, and the Palau Group (Sogen, 1941). *Aedes aegypti* was probably the responsible vector. However, species of the “*scutellaris*” group, and particularly *hensilli*, may also have been involved.

### 5. *Aedes (Stegomyia) scutoscriptus* n. sp.—Figure 27.

*Female.*—Length of wing 2.6 mm. Vertex with broad appressed scales, white median, sublateral and lateral spots, a row of pale scales along eye margin narrowly connected with sublateral spot, numerous dark upright forked scales toward nape; clypeus bare; palpus one-fourth as long as proboscis, broadly white at tip. Thoracic integument dark; scutum with bronzy black scales, a narrow median line forked posteriorly and a

bowed lateral line of silvery scales with a yellowish tinge (fig. 27), a group of broadened white scales over wing base; scutellum with silvery white broad appressed scales and with black ones at apex of mid lobe; pronotal lobes with white broad appressed scales, continued in a broken line across pleuron and above wing base; pleuron with other white patches; wing scales dark except at extreme base of costa; halter knob all pale scaled; femora with a posteroventral pale line, continued onto antero-ventral surface of hind femur and terminating just short of knee spot, knee spots prominent on all femora; tibiae dark; fore and mid tarsi with basal spots on I and II; hind tarsus with basal white marks covering about one-fourth of I, one-third of II, nearly one-half of III and all of V. a few pale scales at base of IV, basal white marks broadly interrupted beneath on I and V, narrowly on III. Abdominal tergites with laterobasal white spots continued to sides of dorsum of II-VII as subbasal spots; sternites with broad basal bands.

*Male*.—Palpus slightly longer than proboscis, two pale bands on long segment, pale basal marks on last two segments; hind tarsal III with pale basal band complete. Genitalia as in figure 27.

*Larva* (description based on 5 paratypes collected on Truk from a tree hole).—Antenna smooth, with a small single hair at about apical two-fifths; clypeal spine curved, very slender and pale; head hair *A* double to quadruple, *B* double or rarely single, *C* single, *d* small and multiple, a little in front of *B*; mentum with 21 to 23 teeth. Shoulder hair 1 triple, 2 and 4 single, 3 double, 5 double or triple, 6 single or double. Comb in a curved row of 6 to 8 strong teeth with small lateral denticles extending halfway to apex of shaft; first pentad hair double to quadruple, second and fourth pentads single, third pentad with 3 to 5 branches, fifth pentad with 2 to 5 branches; siphon about 2.4 times its basal diameter, with a somewhat curved row of 7 to 17 pecten teeth, each with 1 or 2 lateral denticles; siphon tuft double or triple, rarely quadruple, placed at middle of siphon; anal segment almost completely ringed, bearing a lateral hair of 2 long, equal branches; gills large, nearly equal, longer pair 1.5 to more than 2 times length of anal ring; 8 to 10 anal hair brushes; osc single, isc double.

*Type* (U. S. National Museum No. 57755).—Male, Moen I., Truk Atoll, November 29, 1945, reared from rot hole in coconut tree (R. L. Ingram).

*Paratypes*.—One hundred and three males, 51 females and 28 larvae (on slides), Moen, Uman, and Udot Islands, Truk Atoll, November and December, 1945, reared from tree holes (R. L. Ingram).

*Biology*.—Larvae were found commonly in tree holes and to a lesser extent in artificial containers. When found in the latter the water was fresh and unpolluted. Adults were not captured in nature nor observed to feed.

*Distribution*.—Truk Atoll: Moen, Uman, Udot and Tol Islands.

*Systematics*.—In many respects this species is intermediate between *aegypti* and members of the "*scutellaris*" group. The hind tarsal markings (fig. 27) are unique, however. The scutal pattern of *galloisi* Yamada from Japan is somewhat similar, but *galloisi* has all hind tarsal segments with basal bands. The larva has the pecten somewhat curved across the siphon as in members of the *pandani* group, but less pronounced.

6. *Aedes (Finlaya) sp. in niveus group*<sup>7</sup>.

*Biology*.—Larvae occur in coconut shells and artificial containers.

*Distribution*.—Palau Group, Peleliu and Garakayo Islands (C. K. Dorsey).

7. *Aedes (Finlaya) sp. in the kochi group*<sup>8</sup>.

*Biology*.—Larvae occur in axils of *Pandanus*.

*Distribution*.—Palau Group: Angaur (G. Starkey and J. Webb) and Garakayo Islands (C. K. Dorsey).

8. *Aedes (Aedes) sp.*

A single female specimen was collected on Moen Island, Truk, resting in a tent in the early morning (R. L. Ingram). In the absence of males or larvae the species cannot be identified.

9. *Aedes (Skusea) lamelliferus n. sp.*—Figures 28, 62.

*Female*.—Length of wing 2.7 mm. Vertex covered with broad appressed scales, dark except for a few pale scales on nape, a small sublateral spot and a few lateral scales; dark upright forked scales on nape and a row pointing forward over eyes toward middle; mouth parts dark, palpus one-sixth as long as proboscis, with a few long bristles. Thoracic integument dark, pleuron a little lighter; scutum with bronzy black scales, some light ones in front, a dense clump of dark bristles over wing base; scutellum with dark broad appressed scales on all lobes; apn with pale broadened scales; ppn with a few dark broad scales; pleuron with large patches of dull pale scales, upper mesepimeron with a group of slender bristles arising from a patch of small translucent scales just above a patch of pale scales, no lower mesepimeral bristle; scales of wing and halter knob dark; legs dark except on basal two-thirds of femora posteriorly, hind femur also pale anteriorly toward base. Abdomen all dark above, tergites with latero-basal pale spots, covering all of I laterally; sternites with basal pale bands.

*Male*.—Palpus nearly cylindrical, three-fourths to four-fifths as long as proboscis. Abdominal spots barely visible from above, larger than in female, that on II extending nearly whole length of segment. Genitalia as in figure 28, dististyle tooth triangular and leaflike.

*Larva* (description based on 5 paratypes collected on Truk from fresh and brackish water in palm axils).—Antenna smooth with single hair inserted at apical two-thirds; clypeal spine curved, slender and pale; head hair *A* with 5 to 6 branches, *B* single or double, *C* single, *d* small and multiple, placed slightly in front of *C*; mentum with about 23 teeth. Shoulder hair 1 with 3 or 4 branches, 2 single, 3 single to quadruple, 4 double or triple, 5 and 6 with about 6 branches. Comb with nearly 100 slender, apically fringed teeth; first and third pentad hairs with 2 to 5 branches, second and fourth pentads single, fifth pentad single or double; siphon (sclerotized portion) about 2.6 times its basal diameter, no acus, pecten of 7 to 12 slender, fringed teeth, a few of which extend onto the unsclerotized basal portion of siphon, siphon tuft a single bristle inserted at middle; anal segment about one-third ringed, bearing a single lateral hair; gills

<sup>7</sup>This species is in manuscript by K. L. Knight.

<sup>8</sup>This species is in manuscript by G. Starkey and J. Webb.

unequal, varying in length from shorter than anal ring to nearly twice as long; about 10 anal hair brushes; osc single, isc with 9 to 13 branches.

*Type* (U. S. National Museum no. 57754).—Male, Moen Island, Truk Atoll, December 11, 1945, reared from fresh water in a nipa palm axil (R. L. Ingram).

*Paratypes*.—Forty males, 70 females and 23 larvae (on slides), Moen Island, Truk Atoll, December 1945, reared from fresh and brackish water in palm axils and tree holes in a mangrove swamp area.

*Biology*.—Larvae occur in mangrove swamps where they are found in both fresh and highly brackish water of palm axils and tree holes. Adults were taken biting in mangrove swamps at midday and near a swamp in the early evening. In view of the abundance of larvae in swamps (nearly every palm axil contained numerous larvae) and the fact that few adults attempted to bite, it appears that either man is not the preferred host or that the desired feeding time is not during the day.

*Distribution*.—Truk Atoll: Moen and Tol Islands. Four females, probably of this species, reared from an artificial container by C. K. Dorsey, are in the National Museum collection from Peleliu Island. Males are needed to verify the identification.

*Systematics*.—Edwards (1932) restricted the subgenus to four species, and one more was added by Brug (1939). These are *amesi* (Ludlow), *furvus* Edwards, *pembaensis* Theobald and *kabaenensis* Brug. *Ae. lamelliferus* differs from all of these in having a leaflike dististyle process as well as other genitalic peculiarities. The male palpi are distinctly shorter than the proboscis in *kabaenensis* and *lamelliferus*. In the others they are nearly as long or longer. *Ae. kabaenensis* is distinctive in having a slender dististyle. The larva of *lamelliferus* closely resembles that of *amesi*, of which we have seen Philippine specimens. However, *lamelliferus* has head hair d anterior instead of posterior to B. Brug (1939) figures the larva of *kabaenensis* as having both the antennal and siphon tuft with four branches.

10. *Culex (Lophoceraomyia) carclimensis* n. sp.—Figures 40, 71.

*Female*.—Length of wing 2.5 mm. Vertex with dark narrow curved scales, lighter toward side, a lateral spot of pale broad appressed scales, entire vertex covered with golden brown upright forked scales; mouth parts dark, palpus one-seventh as long as proboscis. Scutal integument dark with a submedian pale line and pale lateral margin; scutal scales dark; many strong bristles in front of scutellum submedially; scutellar scales narrow and dark; pleuron pale green or pale brown with a large dark central area from propleuron to upper mesepimeron, a few inconspicuous pleural scales, one lower mesepimeral bristle; wing dark scaled; halter knob with dull brown scales; legs dark except for a posterior line which extends onto anterior surface of mid and hind femora. Abdominal tergites with small lateral pale spots on III-VII.

*Male*.—Torus without a knob; flagellum with specialized setae on VI-XI (counting torus as segment I). Proboscis with a transverse baso-ventral row of stiff bristles. Palpus with a finger-like process at extreme base beneath, about as long as proboscis, last two segments sparsely haired, last segment with a few stout apical bristles. Genitalia as in figure 40, basistyle without a row or group of strong setae along inner side.

*Larva* (description based on 5 paratypes collected on Truk from a tree hole).—Antenna with scattered spicules, constricted and tufted at apical two-sevenths, darkened only at base, apical and subapical bristles about equal in length; clypeal spine strong and dark; head hair *A* with 6 to 9 branches, *B* with 3 to 5 branches, *C* with 5 to 7 branches, *d* single and considerably anterior to *B*; mentum with about 27 teeth. Shoulder hairs 1, 2, 5 and 6 single, 3 single to triple, 4 single or double. Comb of 28 to 34 apically fringed teeth; first and fifth pentad hairs double or triple, second and fourth pentads single, third pentad with 5 to 7 branches; siphon about 5 times its basal diameter, with 4 to 8 pecten teeth, last pecten sometimes beyond first tuft, 4 subventral triple or quadruple tufts, the last small and more widely spaced; anal segment with a complete sclerotized ring bearing a short single to triple lateral hair; gills nearly equal, bluntly pointed, hardly 2 times as long as anal ring; about 12 anal hair brushes of which one or two are small and anterior to barred area; osc single, isc with 3 to 5 branches.

*Type* (U. S. National Museum no. 57756).—Male, Fala Island, Truk Atoll, December 4, 1945, reared from larvae collected in a tin can (R. L. Ingram).

*Paratypes*.—Thirty-five males, 46 females and 32 larvae (on slides), Moen and Fala Islands, Truk Atoll, November and December 1945 (R. L. Ingram).

*Biology*.—Larvae occur in tree holes, artificial containers, coconut shells and husks, and taro leaf axils. In artificial containers they appear to prefer polluted water. Adults were not observed to bite.

*Distribution*.—Truk Atoll (Moen, Tol, Udot, and Fala Islands).

*Systematics*.—This species falls into the *fraudatrix* group of Edwards (1932), which is characterized by a transverse row of stiff bristles on the male proboscis beneath; male palpus at least nearly as long as proboscis and with a basal fingerlike projection, a simple male torus, and specialized setae on male antennal segments VI to X or XI. Except for *hilli* Edwards, the other species of the group, *cinctellus* Edwards, *fraudatrix* Theobald, *fulleri* Ludlow, *buxtoni* Edwards, *niger* Leicester, *quadripalpis* Edwards, *rubithoracis* Leicester, *josephinae* Baisas and *pachecoi* Baisas all have the last 2 segments of the male palpus very hairy and bristly. Beside the weakly haired male palpus, *carolinensis* also resembles *hilli* in having no definite row or group of large bristles on the inner side of the basistyle. It differs from *hilli* in having yellow or pale brown upright vertex scales instead of nearly black ones. Also, *hilli* has a few strong bristles on the subterminal male palpal segment and these are not present in *carolinensis*. The larva of *carolinensis* has an unusually short siphon for the subgenus and it is the only described species in which the longest tufts are one-third as long as the siphon.

## 11. *Culex (Culiciomyia) pullus* (Theobald).

*Culiciomyia pulla* Theobald 1905. Ann. Mus. Nat. Hung. 3: 87 (type locality: New Guinea).

*Biology*.—Larvae have been reported from artificial containers, ground pools and tree holes. The only Caroline collection was made by C. K. Dorsey from a tin can.

*Distribution*.—Australia, Solomon Islands, New Guinea, New Britain, New Ireland, Amboina, Palau Group (Peleliu).

*Systematics.* No adults are at hand from the Carolines. Because of the similarity of *pullus* and *nigropunctatus* Edwards in the larval stage, the above identification may be incorrect. According to Barraud (1934), *pullus* has a brown rather than black velvety spot on the mesepimeron.

**12. *Culex (Culex) annulirostris* Skuse—(See fig. 49)**

(For description and further notes, see p. 17.)

*Biology.*—Larvae are found commonly in artificial containers and ground pools. It was the most abundant species on Truk at the time of American occupation in November 1945 and adults were a serious pest in the evening.

*Records.*—Truk Atoll: Moen, Fala, Tol, and Udot Islands (R. L. Ingram); Ulithi Atoll (R. H. Baker).

**13. *Culex (Culex) sitiens* Wiedemann—Figure 48.**

(For description and further data, see p. 18.)

*Biology.*—On Truk several collections were made by the junior author from brackish water in a boat on the beach. Palau specimens in the National Museum collection are from a brackish swamp, a tin can and an isolated pond in a large swamp.

*Records.*—Truk Atoll: Moen Islands; Palau Group: Angaur I. (G. Starkey and J. Webb), Peleliu Island (C. K. Dorsey); and Ulithi Atoll (G. Hensill).

**14. *Culex (Culex) quinquefasciatus* Say—Figure 51.**

(For description and further notes, see p. 8.)

*Biology.*—On Truk, larvae were found very commonly in all types of artificial containers. The most frequent types were wooden buckets and metal drums. Larvae were also found commonly in polluted ground pools in door-yards of native huts. Specimens were taken once from a rot hole in a coconut tree. This species was always found near human habitations or abandoned Japanese houses. Several adults were captured from gun implacements in large hillside tunnels and many were found in a large damp tunnel used as a radio shack.

*Records.*—Truk Atoll: Moen, Tol, Udot, Uman, Fala, and Dublon Islands; Palau Group: Peleliu and Angaur Islands; Ulithi Atoll.

*Relation to Disease.*—Filariasis is distributed widely in the Carolines, and *quinquefasciatus* is presumably the primary vector.

## MOSQUITOES OF THE MARIANA ISLANDS

The Mariana group comprises 15 islands which extend north to south over approximately 400 miles. The principal islands are Guam, Rota, Tinian, and Saipan. Material in the National Museum is from these four islands only, and for that reason the others are not treated.

The islands are somewhat mountainous with elevations of 1,612 feet on Rota, 1,554 on Saipan, 1,334 on Guam and 564 on Tinian. Common trees are coconut, breadfruit, hardwoods (such as ifil), *Pandanus*, and banana. Many animals have been introduced, including cattle, horses, goats, pigs, deer, carabaos, cats, and dogs, but there are no large native animals. Climatic conditions are similar on the four islands. On Guam April is the driest month. The rainy season is from June to November with an average rainfall of 5 to 15 inches a month. Temperature varies little throughout the day or the months of the year, and the humidity is high, averaging about 82 per cent.

Dengue is the outstanding mosquito-borne disease. Epidemics have usually occurred in late summer, correlated with the rainy season and consequent increase in *Ae. aegypti* and *albopictus*, the dengue vectors. Large epidemics have occurred on Guam where *aegypti* appears to be the sole transmitter. However, on Tinian and Saipan, where equally large epidemics took place during American occupation, reports indicate that *albopictus* was the primary vector.

Since 1912 there have been no reports of filariasis on Guam. However, according to Kindleberger (1912), there were 12 cases prior to that time. In an extensive discussion of the diseases of the Marianas, von Prowazek (1913) did not mention the disease except to state that it was common among immigrants from Samoa. The Japanese have imported thousands of Okinawans to Saipan, Tinian, and Rota, primarily to work in the sugar industry, and the disease has probably been established on these islands where the vector (*C. quinquefasciatus*) is common.

A total of 12 species of mosquitoes is known, all in *Aedes* and *Culex*. Of these, four *Aedes* and two *Culex* appear to be endemic.

Prewar collectors were R. G. Oakley, O. H. Swezy, D. T. Fullaway (Guam); and T. Esaki (Saipan, Tinian, and Rota). Recent collectors have been S. F. Bailey, R. H. Baker, G. E. Bohart, H. E. Cott, W. G. Downs, P. Eschmeyer, E. L. Gilbert, J. Greenberg, D. G. Hall, H. S. Hurlbut, G. R. Norris, G. Starkey, B. V. Travis, A. B. Weathersby, J. Webb, and the authors.

### KEY TO THE MOSQUITOES OF THE MARIANAS

#### Adults

1. Scutum with well defined silvery lines on a dark background; tarsal segments with silvery basal bands ..... 2
- Scutum without well defined silvery lines on a dark background ..... 4
2. Scutal pattern lyre-shaped with narrow submedian lines and bowed lateral ones (fig. 16); pleuron with silvery spots..... *Aedes aegypti* (p. 37)

Scutal pattern essentially consisting of a single median stripe narrowed posteriorly .....	3
3. Pleuron with silvery spots; hind tarsus with complete white bands.....	
..... <i>Aedes albopictus</i> (p. 35)	
Pleuron with a silvery linear arrangement; hind tarsus with incomplete white bands .....	
..... <i>Aedes guamensis</i> (p. 35)	
4. Scutum with a distinct narrow golden median line, posterior sublateral golden lines and golden lateral margin .....	5
Scutum without a distinct narrow golden median line .....	7
5. Halter knob with all dark scales; male dististyle with a single subapical tooth .....	
..... <i>Aedes pandani</i> (p. 38)	
Halter knob with mostly pale scales; male dististyle with a double subapical tooth .....	6
6. Scutellum with yellowish narrow curved scales at base of mid lobe and broad appressed ones at apex; fourth hind tarsal with a basal white band covering one-third to one-half of segment; female usually without complete tergal bands except on VII .....	
..... <i>Aedes rotanus</i> (p. 39)	
Scutellum with yellowish broad appressed scales only; fourth hind tarsal with at most a weak basal band; several abdominal tergites in female with complete or nearly complete basal bands .....	
..... <i>Aedes saipanensis</i> (p. 40)	
7. Scutellum with broad appressed shining whitish scales; tarsi all dark or faintly yellowish at bases of some segments .....	
..... <i>Aedes oakleyi</i> (p. 41)	
Scutellum with narrow dull pale or dark scales .....	8
8. Proboscis dark or with an indefinite pale area .....	9
Proboscis with a well defined pale band at about the middle .....	10
9. Hind tarsus with narrow pale basal bands; abdominal tergites with the pale bands incised at middle on some of the segments .....	
..... <i>Aedes vexans nocturnus</i> (p. 41)	
Hind tarsus unicolorous; abdominal tergal bands with convex (especially in female) or straight margins .....	
..... <i>Culex quinquefasciatus</i> (p. 44)	
10. Abdominal tergal bands occupying one-half or more of segments II to VII, all usually produced at mid-line of body; mid femur unspeckled in front; vertex and scutum mostly covered with pale whitish yellow scales .....	
..... <i>Culex litoralis</i> (p. 43)	
Abdominal tergal bands occupying less than one-half of segments II to VII; mid femur conspicuously speckled in front .....	11
11. Pale bands on one or more of abdominal tergites III to VI produced in a point at middle; fore tibia with a row of small pale spots in front, associated with a row of bristles .....	
..... <i>Culex annulirostris marianae</i> (p. 42)	
Pale tergal bands of III to VI rather evenly margined; fore tibia with a row of bristles in front but these not associated with pale spots .....	
..... <i>Culex sitiens</i> (p. 43)	

#### Larvae

1. Siphon with a single pair of subventral tufts inserted in or near the middle; antenna not constricted beyond insertion of tuft .....	2
Siphon with several pairs of subventral tufts; antenna constricted beyond insertion of tuft .....	9
2. One or more apical pecten teeth more widely spaced; comb not in a single regular row .....	3
Pecten teeth rather evenly spaced; comb in a single regular row .....	4
3. Comb of about 50 apically fringed teeth in a patch; siphon tuft hardly as long as apical pecten tooth .....	
..... <i>Aedes oakleyi</i> (p. 41)	
Comb of about 9 to 14 pointed teeth in an irregular single to double row or in a small patch; siphon tuft considerably longer than last pecten tooth .....	
..... <i>Aedes vexans nocturnus</i> (p. 41)	
4. Thorax and abdomen with many stellate hairs; pecten row curved upward posteriorly .....	5
Thorax and abdomen without stellate hairs; pecten row nearly straight .....	7
5. Pecten teeth without obvious subteeth; clypeal spine usually with 2 to 4 branches .....	
..... <i>Aedes pandani</i> (p. 38)	
Pecten teeth with several denticles scattered along ventral edge; clypeal spine simple .....	6
6. Mentum with not more than 17 teeth .....	
..... <i>Aedes saipanensis</i> (p. 40)	
Mentum with 21 or more teeth .....	
..... <i>Aedes rotanus</i> (p. 39)	



posterior line of pale scales which narrows apically, anterior surface mostly pale on basal five-sixths, pale area trailing off ventrally rather than tapering to a sharp point. All tarsal markings broken by a complete inner dark line, fore and mid tarsi dark or with basal white marks on I and II; hind tarsus with basal white marks covering about outer one-fifth of I, one-fourth of II, two-fifths of III, seven-tenths of IV, and entire length of V. Abdominal tergites with laterobasal white spots which are usually visible in dorsal view as small lateral subbasal spots.

*Male.* Palpus slightly shorter than proboscis, segments with pale basal marks; abdominal tergite VIII with lateral spots or a complete basal band. The genitalia are similar to those of *hensilli* (fig. 21).

*Larva* (description based on 10 specimens collected on Guam from tree holes and artificial containers).—Antenna with a small hair about at middle; clypeal spine very slender; head hairs *A*, *B*, and *C* usually single, *d* multiple; mentum with 19 to 23 teeth. Shoulder hairs 1 and 7 double, 2 single, 3 to 6 single or double. Meso- and metathoracic pleural hairs with a weak basal spine. Comb of 9 to 13 teeth on which the fringe reaches to apical one-third of shaft; fifth pentad with 2 to 5 branches, third pentad with 3 to 5 branches; siphon about 2.2 to 2.5 times as long as its basal diameter, 11 to 13 pecten teeth on basal half of tube closely followed by a siphon hair with 4 or 5 branches (rarely 3 or 6); anal segment with a nearly complete sclerotized ring which is slightly spiculate along its posterior margin and which bears a stout lateral hair of 3 or 4 nearly equal branches; gills stout but pointed, longer pair twice the shorter and as long or somewhat longer than anal ring; osc single, isc triple.

*Biology.*—The larvae occur frequently in artificial containers, coconut shells and tree holes. The species is not a domestic one. During a survey on Guam (Bailey and Bohart, 1945) larvae were found in jungle areas far from human habitations and no infestations were observed closer to houses than 50 feet even though suitable containers were present. Adults are rarely seen in nature and have never been observed to bite man even in heavily breeding areas. This is contrary to habits of most species in the "*scutellaris*" group. In the laboratory, specimens were fed with difficulty on man, lizard, toad and mouse. However, numerous specimens fed readily on a dog in the evening. Judging by the isolated habitats in which this species has been found, its natural host is probably wild fowl or possibly lizards or toads.

*Distribution.*—Guam and Rota: Common and widespread. Saipan: A single collection of larvae from a tin box was made at Marpi Point by J. E. Webb (October 31, 1944). In spite of extensive collections on Tinian by military personnel, the species has not been reported from there.

*Systematics.*—The species can be separated from all others in the "*scutellaris*" group by the hind tarsus which is all dark on the inner side (fig. 22). The basal lobe of the basistyle is very similar to those of *hensilli* and *iversi*. The larva is distinctive in its heavily fringed comb teeth and the short, unequal gills. The lateral hair of the anal segment is also characteristic in having 3 or 4 nearly equal branches (fig. 22).

*Relation to Disease.*—Unknown. Because of its biting habits it is doubtful if this species is concerned with transmission of human disease.

3. *Aedes (Stegomyia) aegypti* (Linnaeus)—Figures 16, 65.

(For description and further data, see p. 6.)

*Biology.*—Larvae occur in artificial containers of all kinds close to habitations. In February 1945, S. F. Bailey and the senior author made an intensive survey of Guam to determine the abundance and distribution of mosquito vectors of dengue and other diseases. Larvae of *aegypti* were commonly found in 50-gallon water drums used by natives, and several heavy infestations were observed in piles of automobile tires. On two occasions larvae were collected in coconut tree holes within a native village. It was frequently associated with *quinquefasciatus* but was never found with *guamensis*, which is not a domestic species. Adults were not observed to bite during the day in nature. However, specimens colonized in the laboratory by H. S. Hurlbut bit readily at all times on man, mouse, and chicken. Because of its limited flight range, the distribution of this species probably takes place chiefly in the egg stage through transportation of artificial containers.

*Records.*—The species occurs on Saipan, Tinian, Rota, and Guam. Its distribution on Guam is more restricted than is generally supposed, according to the survey mentioned above (Bailey and Bohart, 1945). Infestations were found through the central one-third of the Island (fig. 72). Outlying points in this area were the villages of Talofofo, Apra and Dededo. No *aegypti* could be located in the towns of Yigo, Inarajan, Merizo, or Umatac. On Rota we found *aegypti* only at the port of Sonson (or Sanrigo). On Tinian it was found at Tinian Town, at a village a few miles east of Tinian Town (larva in a breadfruit tree hole), and at four small villages north of Tinian Town along the west coast (Bailey, 1946). Its distribution on Tinian can be explained by assuming an original introduction at Tinian Town and a spread northward along the main highway via the agency of man. A similar situation existed on Saipan where it was found at Garapan, Charan Konoa, and a few nearby rural clusters of houses on the west side of the island only (Bailey, 1946).

*Relation to Disease.*—The role of this species in transmission of dengue on Tinian and Saipan is in doubt. The greater abundance and wider distribution of *albopictus* has led most workers to regard it as the major vector. However, epidemiological evidence on Guam, where *albopictus* is unknown, favors *aegypti*. From the latter part of August to the middle of October 1944 several thousand cases of dengue occurred on Guam among military personnel. After an intensive anti-*aegypti* campaign, only a few suspected cases were reported during the following year. The methods used were worked out experimentally by S. F. Bailey and the senior author in February 1945. It was found that *aegypti* foci were located in native villages throughout the middle one-third of the island. Breeding was chiefly confined to 50-gallon metal drums used for water storage. The campaign was directed at reducing the number of 50-gallon drums, covering the remainder with cloth treated with 5 per cent DDT—xylool emulsion, and destroying other containers. The program which began in March was carried out under the direction of S. F. Bailey. More than 10,000 drums were covered in the next few months and *aegypti* became exceedingly rare by midsummer. The treatment of the cloth with residual DDT was found necessary because natives almost invariably left drums incompletely covered. The minute amount of DDT washed through the

muslin and burlap covers by rain was sufficient to eliminate all mosquito breeding for about 3 months. In many areas this apparently resulted in eradication of *aegypti*. A single application of DDT insured control for the life of the cover, which was about 4 to 5 months.

4. *Aedes (Stegomyia) pandani* Stone—Figures 25, 63.

*Aedes pandani* Stone 1939. Proc. Ent. Soc. Wash. 41:162 (type locality: Barrigada area, Guam).

*Female*.—Agreeing with description of *rotanus* (p. 39) except for color of thoracic integument, halter and scutellar scaling, and abdominal markings. Thoracic integument on scutum and pleuron light brown except in spiracular area, not strongly contrasting with color of coxae. Scutellum with dark broad appressed scales on lateral lobe and pale broad appressed ones on mid lobe where there are also a few inconspicuous pale narrow curved scales. Halter knob dark scaled. Abdominal tergites with somewhat oblique laterobasal white spots which are often not visible in dorsal view; spots somewhat enlarged on VI and joined in a subbasal band on VII. Hind tarsus with basal bands occupying about one-sixth of I, two-sevenths of II, two-fifths of III and one-third of IV; last hind tarsal all dark or with a few basal pale scales.

*Male*.—About as in female but with hind tarsal bands slightly narrower. Palpus slightly shorter than proboscis, segments with basal white marks. Basal lobe of basistyle with many similar hairs at its apex; dististyle tooth single.

*Larva* (description based on 10 specimens collected from *Pandanus* leaf axils on Guam).—Agreeing with description of *rotanus* except as follows: Clypeal spine rarely single, usually double to quadruple; mentum with 24 to 29 teeth. Shoulder hair 4 usually single. Pentad hair 3 double or triple; comb of 14 to 21 very narrow but apically fringed teeth; siphon about 2.8 times as long as its basal diameter; pecten of 20 to 27 simple, minutely fringed teeth, set in a sharply upcurved row; siphon hair with 2 to 4 branches; lateral hair of anal segment about as long as head, with 6 to 8 branches; gills slender, unequal, longer pair usually longer than anal ring.

*Biology*.—Larvae occur only in leaf axils. They are common in *Pandanus* and also are found in taro under moist conditions. In spite of this restricted habit, the species was colonized without difficulty by H. S. Hurlbut and larvae were reared on dried animal food in open pans of tap water. Females bite viciously and persistently all during the day and in the early morning and late evening. They will enter houses at night and have been noted attempting to bite in dim light as late as 10:00 p.m. The species is by far the worst mosquito pest on Guam in areas near breeding places. It occurs during the entire year but is somewhat less numerous during dry periods. In the laboratory it fed readily on man, dog, rabbit, and mouse. Eggs were laid on damp filter paper by gravid females confined in small vials. In a cross-mating experiment begun by the authors, eggs, larvae, and adults were obtained from female *pandani* mated with male *rotanus*. The reciprocal cross was unsuccessful although infertile eggs were laid twice. No eggs were obtained from the  $F_1$  generation, and in the absence of the authors the material was lost.

*Distribution*.—The species is known only from Guam and it is found throughout the island wherever *Pandanus* grows.

*Systematics.*—This species is one of a group which is restricted to the Marianas. The nearest known relatives are in the *aegypti* group which are native to Africa. *Aedes pandani* differs from *rotanus* and *saipanensis* by its dark halter knob and the more slender dististyle with a single tooth. The incomplete abdominal markings further separate it from *saipanensis*, and the entirely or mostly broad scaled scutellum distinguish it from *rotanus*. The larvae differ from those of the other two species by the simple pecten teeth (fig. 25) and the usually divided clypeal spine. As a general rule, *pandani* larvae are also paler. This may be associated with the habitat differences but larvae reared under moderate light in the laboratory remained pale for many generations.

*Relation to Disease.*—Unknown. Its somewhat distant relationship to *aegypti*, its abundance and voracity bring *pandani* under suspicion as a carrier of dengue. Epidemiological evidence to date is negative, however.

#### 5. *Aedes (Stegomyia) rotanus* n. sp.—Figure 24.

*Female.*—Length of wing 2.7 mm. Vertex with broad appressed scales and a few short dark upright ones toward nape, a median whitish stripe extending between eyes, a very narrow pale margin to the eye ending in a large sublateral yellowish white spot, a similar partially connected lateral spot; a yellowish white ring on torus; palpus white tipped; proboscis black. Scutal scales dark brown with a narrow median golden line which forks posteriorly, a submedian posterior golden line, turning laterally in front and weakly connected with a lateral golden marginal line continued over wing base, scutal integument dark brown; scutellum with dark broad appressed scales on lateral lobes, mid lobe with many yellow narrow curved scales at base and yellow broad appressed ones at apex; apn with pale broad appressed scales; ppn with similar scales below and a mixture of dark and golden narrow curved scales above; pleuron dark brown, with two large patches of whitish scales on sternopleuron, one on mesepimeron and a line between wing base and spiracle; wing dark scaled; halter knob almost entirely pale scaled; femora mostly pale posteriorly, hind femur with a pale stripe, narrowed and more ventral toward apex where it is narrowly broken, knee spots on all femora yellowish; tibiae dark with some dull pale scales ventrally; fore and mid tarsi with basal white marks on I and II, hind tarsus with basal pale bands covering one-fifth of I, one-third of II, two-fifths of III, almost one-half of IV, two-fifths of V, those on I and V incomplete ventrally. Abdominal tergites with oblique laterobasal white spots, hardly visible in dorsal view, tergites III to VI with a pair of white sublateral subbasal spots, these joined into a single spot on VII (and joined with lateral spots in some paratypes), venter mostly white on I to IV, with subbasal white bands on V to VII.

*Male.*—Palpus slightly shorter than proboscis, segments with basal white marks. Abdominal tergites with oblique lateral spots which are subbasal in dorsal view, the spots are large on VII and approaching or joined on VIII. Genitalia (fig. 24) with stronger bristles dorsally and medially on basal lobe, dististyle with subapical breadth about 1.5 times its subbasal breadth, with a double subapical tooth.

*Larva* (description based on 9 paratypes collected from artificial containers and *Pandanus* leaf axils).—Antenna with a moderate hair at about middle; clypeal spine slender and single; head hair *A* single to triple, *B* single or double, *C* single, *d* multiple; mentum (fig. 24) with 21 to 25

teeth. Thorax and abdomen with many stellate hairs: shoulder hair 1 long and multiple, 2 long and single, 3 and 5 stellate, 4 double, 6 long with 4 or 5 branches. Abdominal tergites with stellate anterior and posterior submedian hairs, a posterior sublateral stellate hair and a lateral one: comb of 16 to 22 slender, apically fringed teeth: pentad hairs 1 and 5 stellate, 2 and 4 single, 3 with 1 to 5 branches: siphon slightly less than twice its basal diameter, with 16 to 25 pecten teeth in an upward-curving arc on basal two-thirds of tube, most teeth with 3 or 4 denticles along basal half: siphon tuft of 2 or 3 branches inserted at about apical one-third of tube: a strong subapical subdorsal bristle: anal segment short and broad; anal ring nearly complete, lateral hair usually with 5 branches which are about half as long as head, set between 2 patches of long spicules: gills unequal, longer pair at least as long as anal ring: fan of about 10 hair brushes; osc with about 5 branches, isc with about 10 branches.

*Type* (U. S. National Museum no. 57957).—Male, north side Rota Island, Marianas, October 26, 1945, reared from *Pandanus* axil (R. Bohart and R. Ingram).

*Paratypes*.—Forty-eight males and 31 females, Rota, October 26, 1945, reared from *Pandanus*, tree holes and artificial containers (R. Bohart and R. Ingram).

*Biology*.—Larvae occur commonly in *Pandanus* axils and less frequently in tree holes and artificial containers. We have collected them associated with *aegypti* in flower pots, and with *guamensis* in coconut and breadfruit tree holes. They were found in a cement cistern by H. S. Hurlbut. The adults appear to be less voracious than those of *pandani*. Only a few specimens attempted to bite in heavily breeding *Pandanus* thickets. Adults reared in the laboratory were cross-mated with *pandani*. See remarks under that species. In the laboratory females fed on man and mouse.

*Distribution*.—Widespread on Rota from sea level to 1500 feet elevation.

*Systematics*.—The species is a member of the "*pandani*" group and is more closely related to *saipanensis* than to *pandani*. It differs from *saipanensis* by the numerous narrow scutellar scales, the broken abdominal bands and the somewhat more slender dististyle. The larvae appear to differ primarily in shape and number of teeth of the mentum (fig. 24). This species is the only known *Stegomyia* with narrow scales on the scutellum (*pandani* may have a very few at sides of mid lobe).

#### 6. *Aedes (Stegomyia) saipanensis* Stone—Figure 26.

*Aedes saipanensis* Stone 1945, Proc. Ent. Soc. Wash. 47: 66 (type locality: Saipan).

*Female*.—Description agreeing with that of *rotanus* (p. 39) except as follows: Proboscis usually with a rather distinct ventral line of pale scales. Scutellum with broad appressed scales only. Hind tarsus with white basal bands covering about one-fifth of I, one-fourth of II, one-third of III, one-fourth of IV and V, those on I, IV and V incomplete. Abdominal tergites III to VI with basal pale bands, also I and II sometimes with basal bands.

*Male*.—Markings as in *rotanus* except for differences in proboscis, scutellum and hind tarsus described above. Genitalia with basal lobe

about as in *rotanus* but dististyle usually three times as broad subapically as subbasally, dististyle with a double subapical tooth.

*Larva* (description based on 10 specimens from Saipan, reared from tree holes and *Pandanus* leaf axils).—Agreeing with description of *rotanus* except as follows: Clypeal spine rarely double or triple; mentum with 17 to 21 teeth (fig. 26). Shoulder hair 4 usually triple. Pentad hair 3 with 2 to 5 branches; comb with 14 to 17 teeth; pecten with 13 to 18 teeth; siphon hair with 2 or rarely 3 to 4 branches; lateral hair of anal ring with 4 or 5 branches, rarely 3, 6 or 7; gills stout, unequal, longer pair usually not longer than anal ring.

*Biology*.—Larvae have been found on Saipan in holes of breadfruit and banyan trees, and less frequently in *Pandanus* axils (Stone, 1945). Specimens collected on Tinian by S. F. Bailey and H. E. Cott were taken from papaya tree holes and occasionally in artificial containers. The species bites man but it is less numerous and less persistent than its Guam relative.

*Distribution*.—Known only from Saipan and Tinian.

*Systematics*.—See discussion under *rotanus* and *pandani*. The larval gills of *saipanensis* are nearly always shorter than those of *rotanus*.

7. *Aedes (Aedimorphus) vexans nocturnus* (Theobald)—Figure 69.

(For description and further notes, see p. 15)

*Biology*.—Larvae occur in temporary rainwater pools and sometimes in artificial containers, frequently in great numbers. They are not often found during the drier winter months but are more common in the summer. Adults have been observed to bite at night.

*Records*.—Widespread on Guam and recorded also on Saipan (Magicienne Bay).

8. *Aedes (Aedimorphus) oakleyi* Stone—Figures 33, 68.

*Aedes oakleyi* Stone 1939, Proc. Ent. Soc. Wash. 41: 163 (type locality: Root Farm, Guam).

*Female*.—Length of wing 3 mm. Vertex with pale narrow curved scales and abundant dark upright forked scales in broad median area, laterally with yellowish white broad appressed scales; torus with a few small pale scales; palpus short, apical segment all dark, shorter than basal; proboscis with dull yellow scales along most of basal two-thirds except dorsally. Scutum with reddish brown scales and areas of paler scaling, especially behind apn, along fossal suture and around prescutellar area; scutellum covered with shining yellowish white broad appressed scales and a few narrow ones at sides; apn with pale broad appressed scales; ppn with some pale and some dark narrow scales; pleuron light brown with 2 small patches of pale scales; wing dark scaled; halter knob pale; femora and tibiae with brown scales anteriorly, pale yellow scales posteriorly, tibiae with a distinct yellowish apical spot; tarsi brown, slightly paler at bases of some segments, but without pale bands. Abdomen dark brown with pale yellowish white basal bands, wider and paler laterally; venter entirely pale.

*Male*.—Palpus longer than proboscis by nearly length of apical segment; last two segments with long hairs. Abdominal tergite VIII entirely pale scaled. Genitalia with greatly swollen dististyle (fig. 33).

*Larva* (description based on three specimens collected on Guam from a tree hole and from a tin can).—Antenna with a moderate number of spicules, a hair of about 7 branches inserted at basal two-fifths and reaching about to apex of shaft; clypeal spine slender and attenuated; head hair *A* with 6 to 9 branches, *B* double, *C* triple, *d* very small and multiple, placed slightly in front of *C*; mentum with 36 to 39 teeth. Dorsal submedian hairs of thorax and abdomen (including shoulder hairs 1 to 4) very small; shoulder hairs 1, 5 and 6 single, 2, 3 and 4 usually single but split or frayed, 7 double. Comb of 27 to 50 broad and apically fringed teeth in a patch; first and second pentad hairs set close together and with about 3 and 8 branches respectively, third pentad very short and many branched, fourth pentad single but split, fifth pentad with about 6 branches; siphon about 4.0 to 4.5 times its basal diameter, acus present, 15 to 18 subbasally toothed pecten teeth with most distal tooth more widely spaced, siphon hair at about apical one-third of tube and with about 6 branches which are shorter than apical pecten tooth; anal ring nearly complete, minutely spiculate along posterior margin, lateral hair single but split; about 12 hair brushes of which 3 are anterior to barred area; gills about equal, pointed, about as long as anal ring; osc long and single, isc shorter and with about 7 branches.

*Biology*.—Very little is known about this species which has been observed only a few times. The type series was collected by R. G. Oakley at Root Farm (Barrigada area) from a water drum: A. B. Weathersby took larvae in October 1944 from a tree hole at Yona: R. H. Baker found the species during June 1945 breeding in a tin can 2.5 miles north of Yigo; and a single larva in the U. S. National Museum collection bears the data: Ritidian Point, May 29, 1945, tree hole.

*Distribution*.—Known only from the Guam localities cited above.

*Systematics*.—It is closely related to *alboscuteallatus* (Theobald), agreeing with this species in having white scutellar scales and all dark tarsi. The male palpus of *oakleyi* is longer than the proboscis by the length of the last segment rather than the last two segments, however. Also, the dististyle has a slightly different shape and bristle arrangement.

#### 9. *Culex (Culex) annulirostris marianae*, new subspecies—Figure 49.

*Adult*.—Agreeing with description of *annulirostris* (p. 17) except for a narrow line of dull yellowish pale scales along apices of abdominal tergites II to IV (sometimes also on V and VI).

*Larva*.—Very similar to typical *annulirostris*. Teeth of mentum usually somewhat more blunt; gills usually shorter, often much shorter than anal ring. These characters are variable, however.

*Type* (U. S. National Museum no. 57956).—Male. Charan Konoa, Saipan Island, Marianas, August 24, 1944 (D. G. Hall).

*Paratypes*.—Fourteen males and 34 females, Charan Konoa, Charan Jija, and Tsutsuuran (collected by D. G. Hall, J. Greenberg, C. Alley and J. Webb).

*Biology*.—Larvae have been collected in ground pools, particularly with mud bottoms. They also occur commonly in artificial containers of all kinds. One heavy infestation was observed in a fresh water swamp on Guam by the junior author and two similar situations were noted by S. F. Bailey (1946) on Tinian. We have seen larvae in immense numbers

in concrete cisterns near houses and in agricultural fields on Rota. Adults were not observed to bite man but, in the laboratory at Guam they fed readily on a dog.

*Distribution*.—Saipan, Tinian, Rota, and Guam.

*Systematics*.—See discussion under *annulirostris*. The narrow apical pale bands on the abdominal tergites occur on all material we have seen from the Marianas. Generally the bands are broader and a deeper shade of yellow in Saipan specimens. They are usually more prominent in females than in males.

**10. *Culex (Culex) sitiens* Wiedemann—Figure 48.**

(For description and further notes, see p. 18)

*Biology*.—Larvae of this species have been found in brackish water of coral rock holes and once in a metal boat on the beach. It is sometimes associated with *litoralis* and is most common during the wet season.

*Records*.—Guam (along the coast).

**11. *Culex (Culex) litoralis* R. Bohart—Figure 47.**

*Culex litoralis* R. Bohart 1946. Proc. Biol. Soc. Wash. 59: 43 (type locality: Rota I.).

*Female*.—Vertex with median area covered with pale yellowish narrow curved and upright forked scales, a few submedian dark upright scales, vertex laterally with a large spot of dull white broad appressed scales; palpus pale at tip; proboscis with a pale ring covering one-fourth to one-third of proboscis. Scales of apn, ppn, scutum and scutellum narrow curved and pale yellowish; scutum also with dark curved scales forming a spot in fossal area and a fringe around antescutellar area; scutal scales mostly scimitar-like and imparting a shaggy appearance; pleuron with three small pale spots. Wing dark scaled; halter knob entirely pale. Posterior surface of femora mostly pale, anterior surface of fore and mid femora dark and unspckled, that of hind femur pale on most of basal two-thirds; tibiae dark; tarsi with narrow pale joint bands. Dorsum of abdomen with broad whitish yellow basal bands on II to VII, the bands usually occupying one-half or more of each segment and often produced at midline of body.

*Male*.—Palpus longer than proboscis by the last segment, three pale marks on first long segment, a basal band on subterminal segment, terminal segment with narrow basal and apical bands. Proboscis band occupying about one-fifth its length. Abdominal tergite VIII with a lateral spot. Paraproct with very small basal arm.

*Larva* (description based on 10 specimens collected on Rota and Guam from brackish water).—Antenna constricted and tufted at apical two-fifths, part beyond tuft darkened, basal portion well spiculate; clypeal spine short and very stout, usually pale brown; head hair *A* with 4 to 8 branches, *B* and *C* double or triple, *d* slender and single; mentum with 17 to 19 teeth. Shoulder hairs weak and not reaching beyond middle of head; hairs 1, 2, 3, 5 and 6 single, 4 and 7 double. Comb of 19 to 37 apically fringed teeth in a patch; third pentad with 8 to 10 branches, fifth pentad double or triple; siphon about four times its basal diameter, with 10 to 14 pecten teeth, each with 2 or 3 lateral denticles, an irregular row of 10 to 11

ventral tufts with 5 or 6 branches, a smaller distal tuft often present, a small sublateral tuft of 3 or 4 branches; anal segment less than half-ringed, bearing a single slender hair outside sclerotized area; about 12 hair brushes in barred area; gills very short, stout and globular; oes single, isc double or triple.

*Biology.*—Larvae are found in brackish water of coral rock holes and sometimes in artificial containers along the beach. They are usually pale straw-colored with a contrasting black thoracic spot. However, in dark water they are much darker. Larvae were first collected on Tinian north of Masalog Pt. by S. F. Bailey and H. E. Cott who reared them equally well in fresh, brackish and sea water. The species disappeared during the dry season (Bailey, 1946).

*Distribution.*—Tinian (along northeast and northwest coast), Rota (northeast coast) and Guam (Pt. Ritidian, Tumon Bay, Pt. Oca, Umatac Bay).

*Systematics.*—It is related to *sitiens* and *annulirostris*, differing as indicated in the key. The larva resembles that of *sitiens* in having globose gills but differs in its incomplete anal ring and stouter pecten teeth. We have seen specimens of a similar undescribed species (or subspecies) from New Guinea and the Philippines.

## 12. *Culex (Culex) quinquefasciatus* Say—Figure 51.

(For description and further notes, see p. 8.)

*Biology.*—The larvae are commonly found in all types of artificial containers and in ground pools. On Guam they are frequently associated with larvae of *aegypti* in 50-gallon water drums as well as in other containers. Breeding places such as pools under outdoor shower platforms and water in rolled canvas are sometimes difficult to locate. Larvae were collected once in a polluted tree hole. Adults are a nuisance in the evening, particularly at outdoor movies. Specimens reared in the laboratory by H. S. Hurlbut were fed with difficulty on mouse and man but readily on chicken.

*Relation to Disease.*—Considering the apparent absence of filariasis on Guam, this species is probably not a vector of human disease. However, on Rota, Tinian, and Saipan there are large numbers of Japanese subjects including many Okinawans. In all probability periodic filariasis has become firmly established on these islands, even among the natives. As *quinquefasciatus* is the primary vector on the highly filarial island of Okinawa this is likely to be the case in the Marianas, also.

Control of *quinquefasciatus* in the Marianas, as elsewhere, consists of vigorous clean up of tin cans and other artificial containers, proper disposal of waste water from laundry and sewage, and the use of residual DDT in and under buildings where adults may rest.

## MOSQUITOES OF OKINAWA

The Ryukyu Islands lie in a curved chain between Formosa and Kyushu. The principal island is Okinawa<sup>9</sup>, located near the middle of the group and about equidistant from Formosa, China, and Kyushu. Nearby islands are Ie, Heanza, Takabanare, Hamahika, Ike, Tsugen, Yagachi, Kouri, Izena, Sesoko, and Iheya. Okinawa is about 70 miles long and averages 7 miles wide. It represents the peak of a submerged mountain and is composed of Paleozoic (sandstone, clay, limestone, etc.), and igneous rocks. There is a heavy growth of vegetation in most uncultivated areas, particularly in the northern half of the island which is mountainous, more heavily wooded and with a greater abundance of water. The highest point on Okinawa is Mt. Yonaha with an elevation of 1,650 ft. The terrain in the southern part of the island is low and rolling, and is more extensively cultivated. Terrace farming is carried out on a large scale, even on steep hillsides; rice, vegetables, sugarcane, and tea are important crops. Among common trees are pines, hardwoods, mulberry, bamboo, a narrow leafed *Pandanus*, banana, and cycad. There are no large animals native to Okinawa but there are numerous rats and birds. Deer, wild boar, mongooses, bats, snakes, lizards, frogs, and salamanders are also present. There are many domestic animals, such as goats, pigs, horses, chickens, and cattle, but cats and dogs are uncommon.

The climate is subtropical with a high humidity and a temperature range of 41° to 96°F. (recorded at Naha over a 39-year period). The nights are cool from October to May. The annual rainfall varies in different sections of the island from 65 to 89 inches, with about 200 rainy days each year (Anon., 1944). The period from May to September is the most rainy, but the wet season is not well marked.

Malaria is probably the most important insect-borne disease. Its occurrence on this island appears to be seasonal, however. Of 1,000 thick blood smears taken from natives by an American research group from April to June 1945 only one was positive for malaria. Other workers using different groups of natives had similar results. However, during August and September of the same year many cases of malaria were reported among the natives. In some households 3 or 4 persons were sick at the same time, with typical malaria symptoms.

Filariasis is a very common disease among the local inhabitants. Yokogawa and Yumoto (1939) reported a 21.88 to 35.55 per cent infection in Okinawa Prefecture. This high rate was verified by thick blood smears taken by American workers on Okinawa during occupation by our forces. *Culex quinquefasciatus* is the principal vector, although other species of mosquitoes which have been proven to be suitable intermediate hosts for the development of *W. bancrofti* may be involved. They are *Aedes togoi*, *Anopheles sinensis*, *Culex tritaeniorhynchus*, and *C. sinensis*.

Japanese "B" encephalitis is a serious disease on Okinawa, with a high rate of mortality. In 1945 an epidemic started about the first of July

<sup>9</sup>References to Okinawa in this paper refer to the island proper.

and lasted until September. More than 100 cases were reported, a few of which were among American military personnel. Many other cases undoubtedly occurred since a great number of sick natives did not seek medical care. Japanese and Russian authors have incriminated various species of mosquitoes as vectors. *Culex tritaeniorhynchus*, *C. bitaeniorhynchus* and *Ae. togoi* were found to be vectors in the Soviet Far East (Chagin and Kondratiev, 1943). If this disease is restricted to a cycle of mosquito and man, epidemiological evidence on Okinawa points to *C. quinquefasciatus* as the vector. However, if an animal is required as a reservoir, as many workers believe, the common *C. tritaeniorhynchus*, which feeds readily on horse and man could be the primary vector.

Several epidemics of dengue have been reported from the Ryukyus. During American occupation many cases of a denguelike fever were reported (Johnson et al., 1946). Both dengue vectors, *Ae. aegypti* and *Ae. albopictus* are present on the island, but we found *aegypti* only in the south, whereas *albopictus* was widespread.

The authors were attached to an advance group of Naval Medical Research Unit No. 2 which was assigned the task of making a preliminary survey of the island for epidemic diseases and their vectors. This study was carried out from April to October 1945.

The only species of mosquitoes reported by the Japanese before the war with specific locality records were *C. pipiens pallens* Coquillett (= *C. quinquefasciatus*), *C. mimeticus*, *Armigeres obturbans* (Walker) (= *Armigeres subalbatus*), *Ae. albopictus*, *Ae. aegypti*, *Ae. togoi* and *Anopheles hyrcanus sinensis* (= *An. sinensis*) (Anon. 1931). Eight genera including 33 species are now known of which 8 appear to be endemic. There are many more species in the northern half of the island than in the southern half, particularly in stream canyons along the coast. The richness of the fauna is indicated by the fact that 28 species were collected by the authors in a single canyon near Chizuka over a period of a few weeks. Material in the National Museum and other specimens we have examined were collected by G. F. Augustson, G. E. Bohart, H. Down, W. G. Downs, J. B. Duncan, J. Fluno, J. Gillaspay, C. L. Harnage, K. V. Krombein, T. H. Mailen, P. W. Oman, C. T. Parsons, A. J. Rogers, L. E. Roth, M. L. Smith, J. F. Spitzer, B. V. Travis and the authors. The authors were assisted in many ways by T. Inefuki and T. Myagi (native Okinawans) who helped with the collecting and gave valuable information on terrain. A small amount of material was collected on neighboring islands. Specimens we have examined from Ie were collected by B. V. Travis and K. V. Krombein, from Kerama by L. E. Roth, from Iheya by G. F. Augustson, and from Heanza, Takabanare and Hamahika by the junior author.

The National Museum has four species of mosquitoes collected by J. M. Hutzell on the island of Iwo in the Bonins. These are *Aedes aegypti*, *Ae. togoi*, *Culex vorax* and *C. quinquefasciatus*. As these species all occur on Okinawa, they are not treated separately.

## KEY TO THE MOSQUITOES OF OKINAWA

### Adults

1. Scutellum not divided into lobes; abdominal tergites unscaled; proboscis all dark and about as long as palpus in both sexes; wing spotted..... 2
- Scutellum trilobed; abdominal tergites with overlapping scales..... 3

2. Palpus all dark; scutal integument pale with a continuous dark lateral border as seen in dorsal view; tarsi with narrow joint bands; fringe all dark along posterior margin of wing ..... *Anopheles saperoi* (p. 53)
- Palpus with some white markings; scutal integument in dorsal view not contrasted as above; tarsi with narrow apical bands; wing with a pale fringe spot opposite vein 5.2 ..... *Anopheles sinensis* (p. 51)
3. Wing with definite pale spots; proboscis with a pale band just beyond middle; first pale costal spot extending only onto subcosta ..... *Culex mimeticus* (p. 80)
- Wing dark scaled or speckled, but not definitely spotted ..... 4
4. With 4 or more lower mesepimeral bristles; abdominal tergites with apical pale bands; tarsi without distinct bands, large mosquitoes ..... *Culex vorax* (p. 70)
- With less than 4 lower mesepimeral bristles ..... 5
5. Tarsi unicolorous ..... 6
- Tarsi distinctly banded or mostly yellow ..... 19
6. Scutum with a median silvery line of broad appressed scales; proboscis swollen apically ..... *Harpagomyia genurostris* (p. 54)
- Scutum without a median silvery stripe; proboscis not markedly swollen at apex ..... 7
7. Vein 6 abruptly decurved at apex, not reaching to middle of wing (fig. 2); palpus very short in both sexes ..... 8
- Vein 6 not abruptly decurved at apex; palpus of male at least half as long as proboscis ..... 12
8. Pleural scales with a linear arrangement consisting essentially of a line from apex across sternopleuron ..... 9
- Pleural scales in patches ..... 10
9. Abdominal tergites dark; vertex bright bluish in some lights; thoracic integument brown with some darker areas ..... *Uranotaenia nanseica* (p. 56)
- Abdominal tergites with white apical and lateral spots; vertex not bright bluish; thoracic integument dark brown ..... *Uranotaenia macfarlanei* (p. 55)
10. Scutum with a dark spot over each wing base (fig. 11) ..... *Uranotaenia bimaculata* (p. 57)
- Scutum rather evenly colored ..... 11
11. Scutal integument dark brown except at extreme side, contrasting with straw colored pleuron; abdominal tergites dark ..... *Uranotaenia nivipleura* (p. 57)
- Scutum and pleuron with light brown integument; abdominal tergites usually with inconspicuous pale basal bands ..... *Uranotaenia stonei* (p. 59)
12. Pleuron with fairly large patches of pale scales ..... 13
- Pleuron with few or no scales ..... 14
13. Vertex mainly and scutellum entirely with broad appressed scales; abdominal tergites with large white spots ..... *Armigeres subalbatus* (p. 62)
- Vertex mainly and scutellum entirely with narrow scales; abdominal tergites with basal pale bands ..... *Culex quinquefasciatus* (p. 84)
14. Abdominal tergites entirely dark ..... 15
- Abdominal tergites with pale basal bands ..... 17
15. Vertex with a row of broad appressed scales along eye margin almost to mid point; male palpus longer than proboscis; male antenna with specialized setae on segments VI to X (fig. 39); no lower mesepimeral bristle ..... *Culex tubercis* (p. 74)
- Vertex with narrow scales along eye margin except at side; male palpus shorter than proboscis; male antenna without specialized setae ..... 16
16. Lower mesepimeron with 1 bristle; color of scutal and pleural integument not strongly contrasting; male palpus two-thirds to three-fourths as long as proboscis ..... *Culex hayashii* (p. 71)
- No lower mesepimeral bristle; scutal integument dark except narrowly at side pleural integument pale green or ochreous; male palpus somewhat over half as long as proboscis, subterminal segment enlarged and bowed outward ..... *Culex brevipalpis* (p. 72)
17. Pleuron without dark stripes, anterior median corner of sternopleuron not darkened, a few scales usually visible associated with bristles of lower sternopleuron; male antenna with a small setal process on VII and a longer one on IX ..... *Culex infantulus* (p. 73)
- Pleuron with a dark horizontal integumental stripe or at least darkened at anterior median corner of sternopleuron, pleuron without scales; male antenna without processes ..... 18

18.	Pleuron usually with a rather well defined dark stripe from apn to beneath wing base, and a shorter stripe beginning at anterior median corner of sternopleuron (fig. 42); male palpus longer than proboscis by length of last segment, last 2 segments with many long hairs .....	
	..... <i>Culex pallidothorax</i> (p. 75)	
	Pleuron with a faint stripe across upper part and a small dark spot at anterior median corner of sternopleuron (fig. 41); male palpus longer than proboscis by one-fourth to one-third of last segment, last 2 segments sparsely haired .....	
	..... <i>Culex ryukyensis</i> (p. 76)	
19.	Wing speckled with broadened pale scales .....	20
	Wing not speckled .....	22
20.	Proboscis swollen at apex; proboscis, abdominal tergites and legs yellow speckled with black .....	
	..... <i>Ficalbia luzonensis</i> (p. 60)	
	Proboscis not conspicuously swollen at apex .....	21
21.	Femora and tibiae spotted and banded; hind tarsus with basal and median pale bands on I and basal ones on II to V; abdominal tergites with median, basal and apical ochreous markings and lateral apical white spots .....	
	..... <i>Mansonia uniformis</i> (p. 61)	
	Femora and tibiae speckled; hind tarsus yellow at base of I and with bands covering the joints; abdominal tergites with apical yellowish bands and scattered yellow scales .....	
	..... <i>Culex bitaeniorhynchus</i> (p. 77)	
22.	Scutum with a silvery white median stripe .....	23
	Scutum marked otherwise .....	25
23.	Pleural markings mainly linear .....	
	..... <i>Aedes riversi</i> (p. 65)	
	Pleural markings not linear .....	24
24.	Abdominal tergites with basal bands which are broadened laterally; hind tarsal segment IV with basal three-fifths white .....	
	..... <i>Aedes albopictus</i> (p. 64)	
	Abdominal tergites with basal bands which are not broadened laterally; hind tarsal segment IV with basal five-sixths white .....	
	..... <i>Aedes downsi</i> (p. 64)	
25.	Proboscis dark or at least without a well defined pale band .....	26
	Proboscis with a well defined pale band just beyond middle .....	30
26.	Hind tarsus with basal pale bands only .....	27
	Hind tarsus with joint bands over 1 or more joints .....	28
27.	Scutum with a silvery lyre-shaped pattern (fig. 16); clypeus with 2 silvery spots; last hind tarsal all white .....	
	..... <i>Aedes aegypti</i> (p. 66)	
	Scutum with an indefinite pattern of bronzy brown, yellowish and whitish; clypeus bare; last hind tarsal with a narrow basal band .....	
	..... <i>Aedes vexans nipponii</i> (p. 69)	
28.	Palpus with pale-scaled areas; vertex with dark and white upright forked scales .....	
	..... <i>Aedes togoi</i> (p. 66)	
	Palpus all dark .....	29
29.	Scutum with an anterior median patch of white .....	
	..... <i>Aedes (Finlaya) sp. in gubernatoris group</i> <sup>10</sup> (p. 69)	
	Scutum with a median yellowish line and other lines (fig. 32); vertex with all upright forked scales pale yellow .....	
	..... <i>Aedes okinawanus</i> (p. 67)	
30.	Anterior surface of mid femur speckled with pale scales .....	31
	Anterior surface of mid femur all dark scaled .....	32
31.	Abdominal tergites with apical bands and inconspicuous basal ones; scutum with whitish and ochreous scales on anterior two-thirds, mostly dark scaled behind this .....	
	..... <i>Culex sinensis</i> (p. 79)	
	Abdominal tergites with basal bands; scutum mostly dark scaled, with some variegation .....	
	..... <i>Culex sitiens</i> (p. 81)	
32.	Vertex with upright forked scales all dark; scutal scales minute and coppery brown .....	
	..... <i>Culex tritaeniorhynchus</i> (p. 81)	
	Vertex with dark upright forked scales and numerous pale ones toward middle; scutal scales somewhat shaggy, mixed coppery brown and brownish yellow .....	
	..... <i>Culex vishnui</i> (p. 83)	

#### Larvae

1.	Siphon absent .....	2
	Siphon present .....	3

<sup>10</sup> Adult unknown but included on the basis of group markings.

2. Outer clypeal hair with many branches; posterior clypeal hair much shorter than outer clypeal and multiple; antennal tuft inserted near middle and reaching about to apex of shaft; shoulder hair 1 simple or distally split ..... *Anopheles sinensis* (p. 51)
- Outer clypeal hair with 4 to 7 branches; posterior clypeal hair nearly as long as outer clypeal and single; antennal tuft inserted near basal one-third and usually not extending beyond middle of shaft; shoulder hair 1 with 3 to 6 branches ..... *Anopheles sapersoi* (p. 53)
3. Siphon with only 1 pair of subventral (or sublateral) hair tufts ..... 4
- Siphon with more than 1 pair of subventral hair tufts ..... 17
4. Siphon without a pecten ..... 5
- Siphon with a pecten ..... 7
5. Anal segment incompletely ringed; gills very long and sausage-shaped; antenna with a very small median hair; head hair *f* (behind eye spot) larger than *B* or *C*; siphon about 1.7 times its basal diameter ..... *Armigeres subulbatus* (p. 62)
- Anal segment completely ringed; gills rather small; antenna with a large plumose tuft at or before middle; head hair *f* small ..... 6
6. Siphon valves black and serrate, bearing a long lateral hair; antenna divided into 3 nearly equal portions by hair tuft and subapical bristles, a dark ring at base and at insertion of tuft; head hairs *B* and *C* short; lateral hair of anal segment short; several anal brushes anterior to barred area; comb usually of 2 large blunt teeth ..... *Mansonia uniformis* (p. 61)
- Siphon valves pale, siphon long and narrow; antenna not divided into 3 nearly equal portions, entirely pale; head hairs *B* and *C* very long; lateral hair of anal segment very long; anal brushes all in barred area; comb of 10 to 12 teeth in a regular row ..... *Ficallbia luzonensis* (p. 60)
7. Pecten teeth (or most of them) fringed apically; comb in a single row ..... 8
- Pecten teeth with an apical spine or tooth and with or without lateral denticles ..... 10
8. Head hairs *B* and *C* stout and black; comb teeth sharply pointed; antenna with a small hair near basal one-third; about 9 comb teeth; submedian dorsal hairs of abdomen long and multiple ..... *Uranotaenia macfarlanei* (p. 55)
- Head hairs *B* and *C* slender; comb teeth apically fringed (narrowly in *bimaculata*) ..... 9
9. Anal segment with a complete ring which bears a hair of 4 to 7 branches; first pentad hair shorter than a comb tooth and with many branches; thorax and abdomen without stout, setiform hairs ..... *Uranotaenia bimaculata* (p. 57)
- Anal segment with an incomplete ring which bears a single or double hair; first pentad hair long and single or double; thorax and abdomen with stout, setiform hairs ..... *Uranotaenia stonei* (p. 59)
10. Comb in a fairly regular row ..... 11
- Comb in a patch of many teeth or in an irregular partly double row ..... 14
11. Comb teeth with strong lateral denticles or with fringe extending at least halfway toward apex of spine on most teeth ..... 12
- Comb teeth with a basal fringe which does not extend beyond basal one-third of spine ..... 13
12. Comb teeth with large lateral denticles; meso- and metathoracic pleural hairs with a basal heavy curved spine; lateral hair of anal segment usually with 2 short and equal branches ..... *Aedes aegypti* (p. 66)
- Comb teeth fringed, often double or triple, sometimes with a basal or sub-basal denticle; meso- and metathoracic pleural hairs with a small curved basal spine; lateral hair of anal segment usually strong, with 2 unequal branches ..... *Aedes riversi* (p. 65)
13. Gills unequal, longer pair not more than twice anal ring and about 1.5 times shorter pair; lateral hair of anal segment double to quadruple, longest branch usually reaching to or beyond apex of longer gill; siphon tuft nearly always quadruple; dorsal submedian hairs of abdomen usually with 5 to 7 strong branches ..... *Aedes downsi* (p. 64)
- Gills nearly equal, 2 or more times as long as anal ring; lateral hair of anal segment of 2 unequal branches, longer branch not reaching beyond basal three-fourths of longer gill; siphon tuft usually triple; dorsal submedian hairs of abdomen usually with 3 or 4 weaker branches ..... *Aedes albopictus* (p. 64)

14. Comb of 8 to 11 strong, sharp teeth in a partly double row; one or more distal pecten teeth more widely spaced.....*Aedes vexans nipponii* (p. 69)  
Comb of many apically fringed teeth in a patch; distal pecten teeth not more widely spaced ..... 15
15. Head hairs *B*, *C*, and *d* short, many branched and placed in a transverse line across front of head; siphon stout with a very large tuft at apical one-fourth; gills globular ..... *Aedes togoi* (p. 66)  
Head hairs not as above; siphon moderate, with a moderate tuft before apical one-fourth; gills more developed but not longer than anal ring ..... 16
16. Clypeal spine stout and blunt; head hairs *B*, *C* and *d* in a longitudinal line with *d* halfway between *C* and *B* which are subequal in length.....*Aedes* sp. in *gubernatoris* group (p. 69)  
Clypeal spine slender and sharp; head hairs *B*, *C*, and *d* not in a line; *C* multiple and strong, *B* very long and single ..... *Aedes okinawanus* (p. 67)
17. Siphon with several to many subdorsal hair tufts; only 1 pair of single or double anal brushes; shoulder hair 6 forming a stout fan ..... *Harpagomyia genurostris* (p. 54)  
Siphon with not more than 2 pairs of subdorsal tufts, usually with subventral or sublateral tufts only; more than 1 pair of anal brushes; shoulder hair 6 not developed into a fan ..... 18
18. Siphon tufts and pecten extending along nearly whole length of tube; head hairs *A*, *B*, and *C* long and single ..... *Culex vorax* (p. 70)  
Siphon tufts, pecten and head hairs not as above ..... 19
19. Antennal tuft at or before middle of shaft ..... 20  
Antennal tuft well beyond middle of shaft ..... 23
20. Comb with 4 to 6 strong teeth; siphon with apical dorsal bristle strong, black and at least half as long as diameter of siphon at point of insertion..... 21  
Comb of many apically fringed teeth in a patch; siphon with apical dorsal bristle less than half as long as diameter of siphon at point of insertion ..... 22
21. Subapical bristles of antenna inserted near apex of shaft; siphon with apical dorsal bristle about half as long as diameter of siphon at point of insertion ..... *Culex bitaeniorhynchus* (p. 77)  
Subapical bristles of antenna inserted nearly halfway between apex of shaft and insertion of tuft; siphon with apical dorsal bristle about as long as diameter of siphon at point of insertion ..... *Culex sinensis* (p. 79)
22. Siphon conspicuously swollen toward middle, very narrow at apex; pecten of 4 to 9 teeth; lateral hair of anal segment double to quadruple ..... *Culex pallidothorax* (p. 75)  
Siphon tapering gradually to a narrow and somewhat upturned apex; pecten of 14 to 20 teeth; lateral hair of anal segment short and single..... *Culex ryukyensis* (p. 76)
23. Siphon at least 9 times its basal diameter ..... 24  
Siphon not more than 7 times its basal diameter..... 26
24. Siphon about 12 times its basal diameter, hair tufts minute; fifth pentad hair and isc single ..... *Culex brevipalpis* (p. 72)  
Siphon about 10 times its basal diameter, hair tufts about as long as subapical diameter of tube; fifth pentad hair with about 4 branches; isc triple or quadruple ..... 25
25. Siphon not upturned at apex, usually with a dark band at base and near middle; antenna dark beyond tuft; gills shorter than anal ring ..... *Culex infantulus* (p. 73)  
Siphon upcurved toward apex, not banded; antenna only slightly darkened beyond tuft; gills a little longer than anal ring ..... *Culex tubensis* (p. 74)
26. Comb of 5 to 7 sharp teeth in an irregular row; distal few pecten teeth large, curved and similar in size and shape to those of comb ..... *Culex vishui* (p. 83)  
Comb of many teeth in a patch ..... 27
27. Clypeal spine very short and stout (figs. 47, 48); gills globular..... *Culex sitiens* (p. 81)  
Clypeal spine more slender; gills not globular ..... 28
28. Siphon not more than 4.5 times its basal diameter, usually 3.5 to 4.0 times, apical one-half tapering; 4 pairs of siphon tufts with subapical one often out of line; clypeal spine pale and very slender..... *Culex quinquefasciatus* (p. 84)

- Siphon 6 to 7 times its basal diameter, parallel-sided on apical one-half; more than 4 pairs of siphon tufts; clypeal spine fairly strong and dark ..... 29
29. Head hairs B and C not reaching front of head; fifth pentad hair usually double; most basal siphon tuft about twice basal diameter of tube ..... *Culex hayashii* (p. 71)
- Head hairs B and C or at least B extending beyond front of head; fifth pentad hair usually with 4 or more branches ..... 30
30. Siphon with 4 or 5 pairs of tufts which are usually in an irregular ventral row of 8 to 10 tufts, basal ones nearly twice diameter of tube at base; comb teeth with small lateral spines and a long apical one ..... *Culex mimeticus* (p. 80)
- Siphon with 5 subventral pairs of tufts, the most basal about as long as basal diameter of tube; comb teeth apically fringed ..... *Culex tritaeniorhynchus* (p. 81)

# 1. *Anopheles (Anopheles) sinensis* Wiedemann—Figure 8.

*Anopheles sinensis* Wiedemann 1828. Auss. Zweifl. Ins. p. 547 (type locality: Canton, China).

*Anopheles yesoensis* Tsuzuki 1901. Gunigakkai Zas. No. 123, Suppl. (type locality: Jeso, Hokkaido, Japan).

*Anopheles jesoensis* Tsuzuki (emendation) 1902. Saikingaku Zas. No. 75, p. 93.

*Anopheles hyrcanus sinensis* of authors.

*Female.* Length of wing 5 mm. Vertex with dark erect scales, some white erect scales medially in front, pale hair-like scales between eyes; palpus with a white ring at apical five-sevenths and broadly pale at apex, scales at base nearly erect and about as long as clypeus. Scutum with hair-like scales, integument pale with some darker lines and areas but without a continuous dark lateral border as seen in dorsal view; femora and tibiae dark, slightly paler apically; tarsi with very narrow apical bands on I to III, hind tarsus with a similar band also on IV; wing as in figure 9; costa with a fairly small subcostal spot, a larger preapical spot which is almost continuous with a broad apical fringe spot; vein 4 mostly pale; veins ending in small dark areas along posterior margin of wing; vein 5.2 with a pale fringe spot; vein 6 with a small spot beyond middle and one at apex. Abdominal sternite VII with a small apical scale tuft, abdomen otherwise unscaled.

*Male.* Palpus with pale scales scattered liberally along dorsal surface, last 2 segments forming a club, with long yellowish hairs especially on subterminal segment, last segment mainly pale. Abdominal sternite VII without a prominent scale tuft. Ninth tergite peculiar, U-shaped.

*Larva* (description based on 10 specimens collected on Okinawa from rice paddies).—Preclypeal hair slender and curved; inner clypeals long, single and with bases practically touching; outer clypeal three-fifths as long as inner clypeal and many branched; posterior clypeal split into several branches, less than half as long as outer clypeal; antennal hair inserted at basal two-fifths of shaft, of about 9 branches which extend near or to apex of shaft. Shoulder hair 1 single but split or frayed toward apex; hair 2 moderately stout with about 10 branches; hair 3 single; metathoracic palmate hair weakly developed. Abdominal palmate hairs weak on I, moderate but hardly pigmented on II, well developed with about 18 leaflets on III to VII; leaflets dark on basal two-thirds, pale and many notched on apical one-third, apex slender, approaching a rat-tailed appearance (fig. 8); anterior tergal plates small and with slightly

convex posterior border; pecten with 8 or 9 large teeth and 11 to 15 small ones.

*Biology.*—Larvae have been reported in a variety of situations over the extensive range of this species. We found it commonly outside controlled areas from April to October in rice paddies, in creek pools, in marginal vegetation along large streams, and rarely in large shell holes. It was often found associated with *C. bitaeniorhynchus* in algal situations. On April 14, 1945 we observed mating swarms on the beach at dusk. Both sexes appeared to be dancing in the air from 4 to 7 feet above the ground. During August and September we collected large numbers of adults resting in vegetation along streams, attempting to bite in the shade during the day, feeding on horses at night and entering houses at night to bite humans. We occasionally found adults resting during the day in animal sheds but very rarely in human habitations. At Hentona the largest numbers were observed on the night of August 25 when 100 specimens were collected attempting to bite in a lighted room. The flight was heaviest shortly after dusk and fell off sharply after 11:00 p.m. Various authors have reported that *Anopheles sinensis* is primarily zoophilic, at least in some areas. This did not seem to be true on Okinawa, but it may be argued that, with the great reduction in domestic animals occasioned by the war, the species has been forced to change its habits.

*Distribution.*—India, Burma, Malay Peninsula, Siam, Indochina, China, Formosa, Korea, Ryukyus, and Japan. We found it widespread on Okinawa. Specimens were collected also on Iheya Island.

*Systematics.*—This species has previously been treated by most authors as a subspecies of *hyrcanus* Pallas which was described from the Caspian Sea salt marshes. Very little is known about the latter and in the absence of more evidence of relationship we prefer to treat *sinensis* as a species. Its essential characters are given in the key.

*Relation to Disease.*—During our stay on Okinawa (April to October) *Anopheles sinensis* was one of the commonest mosquitoes. It was found to bite man during the night and to a lesser extent during the day in deep shade (see biology).

Epidemiological evidence indicates that this species was the vector in the malaria epidemic on Okinawa during the summer of 1945. According to Feng (1937), this species is an important malaria carrier in the plains throughout China where many cases of natural infection have been reported. Experimental infections with *P. vivax* have been reported as high as 16.53 per cent by Hindle and Feng (1929), working in Tsinan, Shantung, and somewhat higher by other workers in China. Nevertheless, some authorities believe that *An. sinensis* is not an important malaria vector because of its zoophilic biting habits; others believe that in order for it to play a major role in the transmission of malaria, another more suitable vector must start an epidemic. However, this does not appear to have been true in either case on Okinawa.

This species has also been found infected with *W. bancrofti* in nature (Jackson, 1936; Feng, 1931; Hu, 1939). According to Hu (1939), of 381 specimens fed on a heavily infected case of *W. bancrofti* and dissected after suitable time for complete development, 80 (20.0 per cent) were found with infective larvae. The average number of infective larvae was 3.6 per mosquito. Yamada (1927) considered this species to have a very low suitability as a filarial intermediate host. However, Feng (1935)

considered it to be an important vector of *W. bancrofti* and *W. malayi* in China. Of 34 *An. sinensis* infected on a case with *W. malayi*, all except one were found with filarial larvae, and infective larvae were found on the seventh day in some specimens. Of 27 mosquitoes examined after the incubation period, 26 (96.2 per cent) were found positive for infective larvae (Hu, 1940b). According to Feng (1930) this species is also a vector of *Dirofilaria immitis*.

**NOTES ON CONTROL.**—At the time of the invasion of Okinawa by American forces in April, 1945, larvae of this species were abundant in various types of open fresh water, but because of the prevailing cool weather, few adults appeared to have emerged. Airplane spraying with DDT in oil, which began very early in the operation, was carried out on a large scale and *Anopheles sinensis* became very difficult to find. Due to operational difficulties, spraying was interrupted for about 10 days during May, and at the end of this period, large numbers of larvae and pupae were observed in some rice paddies. Resumption of spraying again reduced the larvae to negligible proportions. The northwestern section of the island, and particularly the area north of Nakaoshi was rarely visited by the spray planes. *Anopheles sinensis* larvae and adults built up to large numbers, and in August and September malaria became a serious problem among the crowded native population. Several planes were dispatched to spray the area and a ground "aerosol" machine treated certain sections. Presumably as a result of these efforts, larval and adults numbers dropped sharply.

**2. *Anopheles (Anopheles) saperoi* R. Bohart and Ingram**—Figures 9, 52.

*Anopheles saperoi* R. Bohart and Ingram 1946. Jour. Wash. Acad. Sci. 36: 46  
type locality: Chizuka, Okinawa).

*Female*.—Length of wing 4.0 mm. Vertex with dark erect scales, some white erect scales medially in front, pale hairlike scales between eyes, rest of head and its appendages dark; palpus with nearly erect scales, longest toward base where they are almost as long as clypeus. Scutum with hairlike scales, integument pale with a continuous dark lateral border as seen in dorsal view; femora and tibiae dark, latter with an apical ring involving base of tarsi; fore femur swollen toward base; tarsi with very narrow pale bands covering the joints, indistinct on last 2 joints of fore and mid legs; wing as in figure 9; costa with a small pale spot just beyond humeral crossvein, a small subcostal spot and a preapical spot; all veins dark at their extreme apices; fringe all dark except for an area at tip of wing. Abdominal sternite VII with an inconspicuous apical scale tuft, abdomen otherwise unscaled.

*Male*.—Unknown.

*Larva* (description based on 3 paratype specimens reared from eggs deposited in the laboratory).—Preclypeal hair slender and curved; inner clypeals long, single and with bases touching; outer clypeal slightly shorter and with 4 to 7 branches; posterior clypeal nearly as long as outer clypeal, single; antennal hair inserted at basal one-third of shaft, of 3 to 4 branches, usually not extending beyond middle of shaft. Shoulder hair 1 with 3 to 6 branches; hair 2 with about 8 branches, relatively slender; hair 3 short and simple; metathoracic palmate hair well developed. Abdomen with palmate hairs weak on I, moderate on II, well developed with about 22 branches on III to VII, leaflets sparsely notched and not rat-tailed; anterior tergal plates small with concave posterior border; pecten with 8 to 9 long and 10 to 11 short teeth.

*Egg*.—Length 0.5 mm. Float large with about 32 ridges, no frill present.

**Biology.**—Larvae of this species were not collected. A gravid female taken from her resting place on a damp rock laid about 100 eggs in a vial in the laboratory. Several specimens were reared to the fourth instar in fresh water. It is probable that the larvae were breeding naturally in rice paddies or streams, but were overlooked because of their scarcity. Females were observed to bite readily in the shade of woods during the day. All of the type series was collected while attempting to feed on the bare legs of native boys.

**Distribution.**—Okinawa: Chizuka and Uka.

**Systematics.**—The systematic position is discussed by Bohart and Ingram (1946). It is related to *gateri* Baisas, *umbrosus* Theobald and *barbirostris* van der Wulp from all of which it differs in having more prominent hind tarsal bands which cover the joints. It can also be separated by a combination of the following characters: Posterior fringe of wing all dark, scutum with a continuous dark lateral margin, pale interruptions present on basal one-third of vein 1, and stems of veins 2 and 4. The larva is distinctive in having a very short antennal tuft, a sparsely branched outer clypeal hair and a long single posterior clypeal hair (fig. 9).

**Relation to Disease.**—Unknown. Because of its scarcity it is an unlikely disease vector.

**3. *Harpagomyia genurostris* (Leicester)**—Figures 13, 60.

*Malaya genurostris* Leicester 1908. Cul. Malaya p. 258 (type locality: Malay Peninsula).

**Female.**—Length of wing 2.5 mm. Vertex with broad appressed scales, a slightly bluish silvery triangle in front projecting between eyes, and a silvery lateral spot, otherwise dark scaled; torus, clypeus and palpus light brown; palpus a little longer than clypeus which is about twice as long as broad and has silvery pruinescence; proboscis with long hairs, apical one-fourth bent upward, swollen and darkened, bearing 4 long bristles at its tip. Scutal integument brown, darker medially and at sides behind, scales dark brown and narrow except for a median bluish-white to violet stripe of broad appressed scales reaching nearly as far as wing base; scutellum with broad appressed scales, dark on lateral lobe, mostly bluish silvery on mid lobe; apn. ppn. coxae and most of pleuron with silvery broad appressed scales, pleuron dark brown; no lower mesepimeral bristle; wing and halter knob dark scaled; anterior fork cell longer than posterior fork cell; legs dark, femora paler behind. Abdominal tergites with brownish black scales and large lateroapical silvery patches on I, II, IV, V and VI, that on IV largest, VII nearly all silvery.

**Male.**—Antenna similar to that of female. Proboscis dark at tip only.

**Larva** (description based on 10 specimens collected on Okinawa from taro axils).—Body integument yellow. Antenna smooth with a small single hair near apex; head capsule broad; head hairs *A* and *d* usually triple. *B* and *C* single or double; mentum broad with about 27 teeth. Shoulder hairs 1 and 2 single, 3 triple, 4 and 5 with 5 to 7 branches. 6 and 7 with many thickened and plumose branches which in the case of 6 form a stout fan. Comb of 30 to 40 apically fringed teeth in an irregular patch; pentad hairs single to quadruple; siphon 4 to 5 times its basal diameter, with a row or a clump and a row of several to many apically fringed teeth on basal two-thirds of tube, a large subventral

tuft of 4 to 5 branches before middle, a ventral row of mostly single hairs on apical one-half, a scattering of subdorsal hairs or tufts, and a stout pair of apical dorsal bristles; anal segment with an incomplete sclerotized ring which has a few fringed spicules posteriorly and which bears a long hair of 3 unequal branches; gills nearly equal, long and bluntly pointed; 1 pair of single or double anal brushes; osc single, isc with about 6 branches.

*Biology.*—Larvae occur in leaf axils. We found them commonly in large taro plants and on one occasion in banana axils. They were sometimes associated with *Aedes downsi*. Adults reared in the laboratory were observed to rest on the fore and mid legs and sway from side to side in a characteristic manner. We did not observe adults in nature, but Edwards (1932) reported that they obtain their food from ants of the genus *Cremastogaster*, for which function the proboscis is specialized. Edwards stated that food was taken from the ant's mouth while the ant stroked the tip of the mosquito's proboscis with its palpi.

*Distribution.*—India, Ceylon, Malakka, Sumatra, Java, Philippines, and Ryukyus. We found it in the northern half of Okinawa at Nago, Shana Wan, Chizuka, and Hedo.

*Systematics.*—Species of this genus are recognized by their brilliant markings and the hairy, swollen, jointed proboscis. *H. genurostris* is closely related to *H. jacobsoni* Edwards but according to Barraud (1934), *genurostris* has the vertex and apn scales silvery white with a bluish sheen rather than blue to bluish violet. The larva of *genurostris* has most of the head hairs multiple, whereas in *jacobsoni* they are single.

#### 4. *Uranotaenia macfarlanei* Edwards—Figures 10, 57.

*Uranotaenia macfarlanei* Edwards 1914. Bul. Ent. Res. 5: 127 (type locality: Hong Kong, China).

*Female.*—Length of wing 2 mm. Vertex with broad appressed scales, dark in median area, margined with white along eye, laterally with 2 spots of pale scales; palpus projecting slightly beyond clypeus, palpus and proboscis dark. Thoracic integument dark brown; scutum with brownish to ochreous scales, a white lateral line from wing base to corner of ppn; scutellum with pale brown broad appressed scales; ppn bare; apn with a line of white broad scales continued across sternopleuron; other pale scales in a small patch on lower sternopleuron; an indistinct greyish integumental area on mesepimeron. 1 lower mesepimeral bristle; wing veins dark except for a row of pale scales along basal one-fourth of vein 1; halter knob dark; coxae with small white spots; femora pale toward base behind, apices of femora and tibiae indistinctly pale; tarsi dark. Abdominal tergites with large white apical spots on I to V, those on I and V continued to sides beneath, VI with an indistinct median apical pale area, II, III, IV and VI with small lateroapical (ventral) pale spots, VII dark.

*Male.* Markings about as in female except that in many specimens there are a few pale scales at middle of vertex. Palpus as in female. Dististyle about 4 times as long as broad.

*Larva* (description based on 14 specimens collected on Okinawa from a pool in a cave).—Antenna and head capsule black; antenna short and cylindrical with a short single hair at basal one-third to two-fifths, shaft

sparsely spiculate; clypeal spine stout and curved; head hair *A* triple or quadruple. *B* and *C* very stout and single. *d* triple and slightly in front of *B*; mentum with about 13 teeth. Shoulder hairs 1, 2, 5, and 6 single, 3 with 7 or 8 branches, 4 and 7 double; dorsal submedian hairs of thorax and abdomen long and many branched. Lateral abdominal hairs of III to VI with 6 to 10 branches; comb of 3 to 10 sharp teeth on a very large plate; first pentad hair with 4 to 6 branches, second pentad split near middle, third pentad with 6 to 9 branches, fourth pentad single, fifth pentad with 3 to 11 branches; siphon light brown, about 4 times its basal diameter, with an acus, pecten of 8 to 12 apically fringed teeth on basal half of tube followed at middle of tube by a hair of 3 to 12 branches; lateroventral valve with a subapical twisted hair which is as long as apical diameter of siphon; anal segment enclosed by a sclerotized ring which has long posterior spicules and a quintuple hair; gills slender, pointed and at least as long as anal ring; 10 anal brushes of which anterior pair is very short; osc double, isc double or triple.

*Biology*.—Brug (1932) described larvae collected in a small leafy pool in Java. Feng (1933) recorded the larvae from shady, sand-bottomed pools in hilly streams in China. On Okinawa we found them during September in a cave pool where many specimens were clustered around a rotten log. A few were also collected at different times in leafy rock pools along a stream. Larvae lie almost horizontal to the water surface and move jerkily when disturbed. This is in contrast to the *Aedes*-like actions of *stonei* and *bimaculata*. Adults were collected in damp situations close to a stream. They were not observed to bite.

*Distribution*.—Assam, Malay Peninsula, Sumatra, Java, China and Okinawa. We found them only in a stream valley west of Chizuka.

*Systematics*.—The dark body integument with prominent pleural stripe (fig. 10) and distinctive abdominal spots are outstanding features. It is related to *campestris* Leicester, but according to Barraud (1934), it can be distinguished by the absence of a blue tint in the thoracic scales.

##### 5. *Uranotaenia nanseica*<sup>11</sup> n. sp.

*Male*.—Length of wing 2 mm. Vertex with broad appressed scales, brownish to bluish grey except for a border of bluish white ones along eye margin, a light bluish area opposite apn and a small pale lateral spot, a few very short pale upright forked scales toward nape; torus light brown, darker inwardly; clypeus brown; palpus light brown and hardly exceeding clypeus; proboscis dark, a little shorter than abdomen. Thoracic integument brown, darker above pleural scale stripe, toward rear of scutum and on postnotum; scutal scales brownish yellow, a patch of broadened greyish ones over wing base; scutellum with pale brownish broad appressed scales; apn with bluish white broad appressed scales nearly continuous with a similarly colored stripe across upper sternopleuron; ppn bare; sternopleuron with an irregular row of pale scales along posterior margin as well as a stripe on upper part; 1 lower mesepimeral bristle; wing and halter knob dark scaled; legs dark, femora paler behind. Abdominal tergites dark brown; venter paler. Basal lobe of basistyle with 1 very stout bristle, 1 stout bristle and several smaller ones in a clump. Dististyle short, broad basally, narrow apically.

<sup>11</sup> Name derived from the Nansei Islands, an alternative name for the Ryukyus.

*Female and Larva.*—Unknown.

*Type* (U. S. National Museum no. 57757). Male, Chizuka, Okinawa, September 14, 1915, resting on a damp rock by a stream (R. Ingram).

*Paratype.*—Male, Hedo, Okinawa, September 23, 1915, resting on a damp rock by a stream (R. Bohart).

*Systematics.*—This species resembles *annandalei* Barraud and *testacea* Theobald in having bluish scales on the vertex and a line of bluish white scales extending from the head across the sternopleuron. It differs from *testacea* in its all dark tarsi and the presence of some broadened greyish scales over the wing base; from *annandalei* by its brown rather than dark brown scutal integument and the brownish yellow rather than dark brown scutal scales. The larva of *testacea* has not been described but that of *annandalei* is peculiar in having the antenna bearing 3 leaflike plates. Head hairs *B* and *C* are stout, the comb consists of about 4 sharp teeth on a dorsally connected plate and the anal segment is completely ringed (Barraud, 1934).

## 6. *Uranotaenia nivipleura* Leicester

*Uranotaenia nivipleura* Leicester 1908. Cul. Malaya, p. 219 (type locality: Selangor, Malay Peninsula).

*Female.*—No specimens available for description. According to Barraud (1934) it resembles the male except for the plumose antennae of the latter.

*Male.*—Length of wing 2 mm. Vertex with broad appressed scales, dark grey with pale grey border along eye margin, numerous pale grey upright forked scales scattered over vertex; torus and mouthparts dark brown; palpus about twice length of clypeus. Integument of postnotum, scutellum and of scutum except at extreme side dark brown, rest of thorax, coxae and trochanters straw colored; scutum sparsely covered with dark brown scales and a narrow lateral border of pale ones; scutellum with dark brown broad appressed scales; ppn with a few pale translucent broad scales; sternopleuron with some pale scales, 1 lower mesepimeral bristle; wing and halter knob dark scaled; legs dark, femora somewhat paler behind. Abdominal tergites dark. Dististyle moderately slender.

*Larva.*—Unknown.

*Biology.*—Only 2 males of this species were collected, both from deep rock holes in company with adults of *U. stonei*. Barraud (1934) gives the larval habitat as pitcher plants at Singapore and tree holes in the mountains of India.

*Distribution.*—India, Malaya and Okinawa. Our specimens were collected in late August and early September in a canyon back of Chizuka.

*Systematics.*—The dark scutum with its narrow lateral border of pale scales, the pale pleuron and the all dark abdominal tergites distinguish this species.

## 7. *Uranotaenia bimaculata* Leicester—Figures 11, 53, 59.

*Uranotaenia bimaculata* Leicester 1908. Cul. Malaya, p. 226 (type locality: Selangor, Malay Peninsula).

*Female.*—Length of wing 2.5 mm. Vertex covered with grey broad appressed scales, paler along eye margin, many pale upright forked scales; torus brown; clypeus light brown; palpus and proboscis dark, palpus a

little more than twice clypeus, proboscis about as long as abdomen. Integument of postnotum, scutellum and scutum brown; scutum with an oval dark brown spot above wing base; rest of thorax as well as coxae and trochanters straw colored; scutum covered with light brownish scales, paler around front margin; scutellum with dark broad appressed scales; apn and ppn apparently without scales; sternopleuron with pale translucent scales along its hind margin, 1 lower mesepimeral bristle; halter knob and wing dark scaled except for 1 or 2 yellowish scales at base of vein 1; legs dark, femora paler behind. Abdominal tergites dark.

*Male*.—About as in female.

*Larva* (description based on 11 specimens collected on Okinawa from tree holes and cut bamboo).—Antenna black, not spiculate, with a triple hair at apical three-fourths; head capsule light brown; clypeal spine not evident; hair *A* with 9 or 10 branches, *B* and *C* single and rather slender, *d* many branched, placed between *B* and *C*; mentum very narrow and with 13 to 15 teeth. Shoulder hairs 1, 2, 5 and 6 single, 3 triple or quadruple, 4 triple to quintuple, 7 double or triple; submedian hairs of mesonotum, metanotum and abdominal tergites small and inconspicuous. Lateral abdominal hairs of III to VI triple (rarely single or double); comb of 6 to 9 teeth with a narrow apical fringe, situated on a large plate; first pentad hair small and many branched, second pentad single on a plate, third pentad with 5 to 8 branches, fourth pentad single, fifth pentad with 4 or 5 branches; siphon dark brown, about 3 times its basal diameter, somewhat swollen at apical one-third, 17 to 22 apically fringed pecten teeth on basal two-thirds of tube and extending just beyond a tuft of 3 to 5 branches; anal segment with a complete sclerotized ring which is minutely spiculate posteriorly and which bears a hair of 4 to 7 branches; gills equal, rounded apically, somewhat shorter than anal ring; 10 anal brushes; osc single, isc double.

*Egg*.—Length about 0.6 mm.; black, dorsal surface dull granular and delimited by a low ridge, sides and bottom smooth and shining.

*Biology*.—Larvae occur most often in tree holes, but also in cut bamboo and artificial containers. We found them rarely in rock holes. At rest they hang almost vertically from the water surface and when disturbed their movements resemble those of *Aedes aegypti* rather than the more jerky motion of many *Uranotaenia*. We found larvae from July through September. Adults were collected in damp situations along streams and in shrubbery, but they were not observed to bite. In the laboratory a female deposited about 50 eggs flat on the water and singly. Very little has been published on the oviposition of *Uranotaenia* and it has apparently not been described for any of the Oriental species. Paine (1943) described the eggs of the Fijian *U. colocasiae* Edwards as "laid in small parallel-sided rafts". Dyar (1901) said of the American *U. sapphirina* O. S.: "The eggs form a boat-shaped mass floating on the surface of the water."  
\* \* \* Eggs elongate cylindrical, bluntly rounded at the large end  
\* \* \* smooth, the terminal fourth roughly granular." Blanchard (1905) made a statement more in agreement with our observations on *bimaculata*: *Uranotaenia* "eggs resemble those of *Aedes*, laid singly".

*Distribution*.—India, Malay Peninsula, China, Philippines, Ryukyus, and Japan. Okinawan records are from various sections of the island, at Taira (W. G. Downs); Ikebaru, and Metaniku in Mizato Township.

Sobaru, Shido (L. Roth); Koza, Nakasoni, Shana Wan, Chizuka, Okuma, Hentona, Uka, and Hedo (authors).

*Systematics*.—The two dark integumental spots on the scutum are distinctive (fig. 11). The larva and pupa have been described by Roth (1946). He described two forms of larvae differing essentially in the lateral abdominal hair of segments III to VI. In the common form the hair is triple but in a rarer type it is long and single. We have also observed this variation, and one of our specimens has single hairs on one side and triple hairs on the other. Specimens we have seen from Kyushu are of the single hair type. A comparison with known larvae of Chinese species has been given by Bohart (1946a).

**8. *Uranotaenia stonei* R. Bohart and Ingram**—Figures 12, 58.

*Uranotaenia stonei* R. Bohart and Ingram 1946. Jour. Wash. Acad. Sci. 36: 47  
(type locality: Chizuka, Okinawa).

*Female*.—Length of wing 3.5 mm. Vertex with light brown broad appressed scales, lighter around eye margins, a sprinkling of upright brown scales; torus bare, light brown; palpus and proboscis brown, former twice as long as clypeus; proboscis about as long as abdomen. Thoracic integument light brown; scutum with light brown narrow curved scales and many stout dark bristles, a few pale scales anteriorly; scutellum with brownish broad appressed scales; apn with a few light grey broad appressed scales; ppn with inconspicuous translucent broad appressed scales; a few translucent scales on upper sternopleuron just below a small dark integumental spot; lower and upper sternopleural bristles well developed, 1 or 2 lower mesepimeral bristles; postspiracular area darkened; wing and halter knob dark scaled; legs dark brown, somewhat paler on femora behind. Abdominal tergites dark brown with inconspicuous pale basal bands usually present on II to VII.

*Male*.—Abdominal bands somewhat more distinct. Lateral plate of mesosome with five prongs in the position of a partly clenched fist; ninth tergite without bristles along its concave apical margin; basal lobe of basistyle with two stout bristles and several smaller ones.

*Larva* (description based on 15 paratypes collected on Okinawa from rock holes).—Head pale; preclypeal spine short and spatulate; antenna slender with single or double hair at apical two-fifths; head hairs, *A*, *B*, *C*, and *d* placed between antennal bases; *A* with 5 to 7 branches, *B* single and slender, *C* with 2 to 4 slender branches, *d* on a level with *C* and with 2 to 4 short branches; mentum triangular with about 17 large teeth. Shoulder hairs 1 to 3 on a sclerotized tubercle, 1 and 3 double or triple, 2 with 5 to 7 branches, 4 with about 8 branches, 5 and 6 single with 5 very long, 7 triple or quadruple; meso- and metathoracic submedian hairs with 4 setiform branches. Abdominal tergites III and VI with stout setiform sublateral hairs, these also present on dorsum of I, II, IV and V; comb of 15 to 20 apically fringed slender teeth not inserted on a definite sclerotized plate; first and second pentad hairs on a sclerotized area, first and fifth pentads single to triple, third pentad with about 8 branches; siphon pale brown, about 4 times its basal diameter, with a large acus, pecten of about 20 teeth which are apically fringed except for last 1 or 2 which are larger and more widely spaced, tuft of about 7 branches inserted at apical two-fifths of tube; anal segment a little more than half ringed

by a sclerotized plate which has long posterior spicules and bears a short equally branched double hair: about 10 anal tufts, all in barred area: gills slender and pointed, equal, longer than anal segment: osc single or double, isc double.

*Biology*.—Larvae occur in deep rock holes along the banks of streams. They are shy and difficult to find even when adults are abundant. We found a total of 4 larval breeding places, all during late August and September 1945. Three of these were in heavily shaded rock holes and the other was in a hillside spring. This spring was a foot below the surface in gravelly ground and opened to the surface by a hole with a diameter of  $1\frac{1}{2}$  inches. It contained about 2 gallons of water, about 100 larvae and pupae of *stonei* and a few larvae of *Culex tritaeniorhynchus*. Larvae of *U. stonei* hang straight down from the water surface and have a very sinuous motion when disturbed. Adults rest in hillside spring holes and in other damp situations along streams. They were not observed to bite.

*Distribution*.—We found it in northwest Okinawa only, at Genka, Chizuka, and Hedo.

*Systematics*.—This species belongs to a group of inconspicuously marked *Uranotaenia* which is sometimes called "*Pseudoficalbia*". The systematic position of *stonei* was discussed by Bohart and Ingram (1946). It can be distinguished from related species by the light brown vertex scales, the few pale scales at the front of the scutum and the small but definite pleural integumental spots. In the larva the spatulate clypeal spine, stout and simple abdominal setae, and the incompletely ringed anal segment are distinctive characters.

## 9. *Ficalbia (Etorleptomyia) luzonensis* (Ludlow)

*O'Reillia luzonensis* Ludlow 1905. Can. Ent. 37: 101 (type locality: Bayambang, Luzon, P. I.).

*Female*.—Length of wing 3 mm. Vertex with median area clothed with scimitar-shaped pale scales and upright forked bicolored or dark scales, bounded laterally by 4 spots of alternating black and white broad appressed scales: palpus about one-seventh proboscis and broadly pale at tip: proboscis somewhat swollen at apex, roughly dark scaled basally, otherwise yellow with scattered dark scales. Scutum with mixed black and pale scales, a large tuft of long outstanding black scales in front of wing base: scutellum with narrow and broad pale scales on lateral lobe, black and pale broad appressed scales on mid lobe: apn with pale broad and narrow scales: ppn with mixed black and white broad appressed scales: pleuron dark reddish, a velvety spot below spiracle, patches of white scales on sternopleuron and postspiracular area: wing speckled with yellowish and black broad scales, many of which are heart-shaped: halter knob with yellowish scales; femora and tibiae speckled with pale scales: tarsi mostly yellow with some dark speckling. Abdominal tergites yellowish, speckled with black, with a more or less distinct dark longitudinal median stripe.

*Male*.—Palpus five-sixths as long as proboscis, speckled, last segment short and swollen, black and bristly. Proboscis strongly swollen on apical two-fifths. Dististyle with a stout apical spine, basal lobe of basistyle with two large spines; tenth sternite lobe with three sclerotized prongs at apex.

*Larva* (description taken from Barraud (1934), based on specimens from Ceylon and Hong Kong).—Antenna long, shaft pale and spiculate, with

a large median hair tuft, subapical hairs long and single, portion of shaft beyond them only one-half as long as middle section, one of apical hairs long; clypeal spine long and fairly stout, with a subbasal barb; head hairs *A* to *C* long, *A* of about 12 branches, *B* triple, *C* of about 5 branches, *d* short and with about 5 branches. Meso- and metapleural plates each with a long spine. Comb of 10 to 12 fringed and apically spined teeth in a regular row; third pentad with about 6 branches, fifth pentad with about 4 branches; siphon about 5 times its basal diameter, narrowed and somewhat upcurved toward apex, acus present, no pecten, a double lateroventral hair at basal one-third of tube; anal segment short, with a complete sclerotized ring which is spiculate posteriorly and which bears a long single hair; gills equal, about as long as anal ring; about 6 hair brushes in barred area; osc and isc usually triple.

*Biology.*—The larval habitat is recorded by Barraud (1934) as "presumably weedy ponds or swamps". We did not collect larvae of this species but adults of both sexes were found resting among low-growing vegetation over a brook. Also, a male specimen was taken in a dense banana grove. Causey (1937) reports that both sexes were attracted to lights from October to December in Siam.

*Distribution.*—Malaysia (including the Philippines), Siam, China, India, and Okinawa. Our records are Chizuka (August 24-31) and Hedo (September 23).

*Systematics.*—According to Barraud (1934), this species can be separated from the closely allied *elegans* Taylor and *mediolineata* (Theobald) by the median black stripe on the abdomen. The male genitalia are distinctive.

10. *Mansonia (Mansonioides) uniformis* (Theobald)—Figure 14.

*Panoplitus uniformis* Theobald 1901. Monograph Culicidae 2: 180 (type locality: Quilon, Travancore, India).

*Female.*—Length of wing 3.8 mm. Vertex with broad median area covered with pale narrow curved scales and many brown upright forked ones, a lateral spot of pale broad appressed scales; palpus about one-fourth as long as proboscis, yellowish, speckled with black; proboscis yellow with a dark basal band and a broader one just before apex. Thoracic integument dark brown; scutum with minute pale and coppery scales, latter more or less in a broad submedian longitudinal stripe and an area in front of wing base; scutellum, apn and ppn with small white narrow curved scales; pleuron with a patch of pale scales on upper and lower sternopleuron and on upper mesepimeron, no lower mesepimeral bristle; wing speckled with pale and dark broad scales; halter knob with ochreous scales; femora and tibiae spotted and banded; hind tarsus with basal and median pale bands on I and basal ones on II to V. Abdominal tergites with median basal and apical ochreous markings and lateral apical white spots; venter ochreous.

*Male* (described from specimens collected in Assam and Philippine Islands).—Palpus longer than proboscis by most of subterminal segment, terminal segment tiny. Markings of proboscis less distinct than in female. Dististyle stout and pointed; basal lobe of basistyle slender and bearing a notched appendage at its apex.

*Larva* (description taken from Barraud (1934), based on specimens from India).—Antennal shaft rigid and divided into three parts of about

equal length by antennal tuft and subapical bristles, minutely spiculate, a dark ring at base and at insertion of hair tuft; clypeal spine long and conspicuous; head hairs *A* and *B* with 6 to 8 branches, *C* and *d* small with several branches; mentum with 9 to 11 teeth. Comb usually of 2 very long blunt teeth; pentad hairs single or double; siphon very short and conical; valves black and modified for piercing plant tissue, with 2 pairs of long spines; siphon hair double and inserted near apex of tube; anal segment long, completely ringed, not posteriorly spiculate, bearing a small lateral hair of 4 or 5 branches; gills about equal, shorter than anal ring; about 13 hair brushes of which about 4 are small and anterior to barred area; osc and isc many branched and as long as anal brushes.

**Biology.**—Larvae breed in "swamps and pools, especially those thickly overgrown with vegetation" (Barraud, 1934). We collected two females only, taken while biting in a lighted room at night. Adults are well known as vicious bloodsuckers of man and animals in other parts of the world. Causey (1937) collected them in light traps in Siam.

**Distribution.**—Africa, Oriental Region, Japan, and Australasian Region. Our specimens were collected at Hentona.

**Systematics.**—This species can be distinguished from others in the subgenus by the green and brown scutal markings.

**Relation to Disease.**—The development of *W. malayi* in this species was described by Bonne-Wepster and Brug (1937). They considered it to be a good vector in the Dutch East Indies. Also, Feng (1938) states that *W. malayi* completes its development in this species but it is not considered as efficient a vector as *Anopheles sinensis*.

**11. *Armigeres (Armigeres) subalbatus* (Coquillett)**—Figures 15, 61.

*Culex subalbatus* Coquillett 1898, Proc. U. S. Nat. Mus. 21: 302 (type locality: Japan).

*Armigeres obturbans* of authors (not Walker).

**Female.**—Length of wing 4.5 mm. Vertex with dark broad appressed scales except for a median spot, narrow eye margin and a lateral spot of whitish broad scales; a few pale narrow and dark upright forked scales on nape; torus with a patch of white scales; palpus and proboscis dark, latter about five times former. Thoracic integument dark reddish-brown; scutum with dark brown scales, margined from wing base forward with pale scales, a patch of pale narrow and somewhat broader scales in prescutellar area; scutellum with all dark broad appressed scales or with some pale broad scales on all lobes; apn and ppn with pale broad and narrow scales as well as dark narrow ones; pleuron with 4 large patches of white scales, one of these on postspiracular area along with postspiracular bristles; one lower mesepimeral bristle; wing dark scaled; halter knob mostly pale scaled; fore and mid femora mostly pale posteriorly, hind femur mostly pale except for a dark dorsal line; tibiae and tarsi dark. Abdominal tergites dark coppery brown with large lateral white spots. VIII mostly white; venter with very broad basal white bands except on sternite VII which has a narrow subapical white band.

**Male.**—Palpus with terminal segments slender, surpassing proboscis by half of last segment. Dististyle slender, when depressed not reaching the two setae of basal lobe.

*Larva* (description based on 10 specimens collected on Okinawa from artificial containers and cut bamboo).—Antenna smooth, with a minute hair at middle; clypeal spine slender and pale; head hair *A* with about 4 branches, *B* single, *C* double to quadruple, *d* with about 5 branches, located slightly in front of *B*, *f* largest of the head hairs and double or triple; mentum with 13 to 15 teeth; anterior mandible tooth black. Shoulder hairs 2 to 4 very small, 5 and 6 on a plate, 1 and 6 single or double, 2 single, 3 double or triple, 4 and 7 with about 5 branches, 5 double to quadruple. Comb of 9 to 14 apically fringed teeth in an irregular single or partly double row: first, second and fourth pentad hairs small and multiple, third pentad with 5 to 9 branches, fifth pentad single or double and very stout; siphon about 1.7 times its basal diameter, no acus or pecten, a small sublateral double hair at apical three-fourths; anal segment about one-third ringed, a small lateral hair of 2 to 5 branches outside sclerotized area; gills very large and long, equal; about 10 anal hair brushes; osc with 3 to 5 branches, isc with about 5 branches.

*Biology*.—Larvae are generally found in polluted water of artificial containers or cut bamboo. We found them most often in abandoned concrete native latrines, or benjos. Less frequently they were in urns containing rotted sweetpotato peelings, fermenting rice or other food; in abandoned wooden pig troughs; in hay infusions; in taro axils; or in tree holes. They generally occur in great numbers, moving in "schools" with a characteristic fishlike "tail swishing". They are associated with various other larvae, but contrary to the statement of Barraud (1934), they seem to be scavengers rather than predators. However, they seize readily on injured larvae or on adults delayed in the act of emerging. In water grossly polluted by food, the larvae usually show a bright pinkish hue. Adults bite readily in the shade during the day and are often a great nuisance. They will enter houses in the late evening to bite and occasionally remain there overnight. Their usual resting places are among vegetation, on damp rocks, or in livestock sheds.

*Distribution*.—Japan, China, Malay Peninsula, Sumatra, India, and Ceylon. It is abundant and widespread on Okinawa and occurs on the neighboring islands of Ie, Heanza, Hamahika, Takabanare, and Iheya.

*Systematics*.—This species is related to *obturbans* (Walker) and has been confused with it. The relationship is discussed by Barraud (1934) and Bohart (1945). As here understood, *subalbatus* has a somewhat longer basistyle so that the dististyle when depressed does not reach the setae of the basal lobe.

*Relation to Disease*.—Most workers agree that this species is not a suitable vector for filariasis. Specimens collected in nature have been found infected with early stages of *W. bancrofti* but transmission experiments have been entirely negative. Hu (1935) reported that all of 582 females collected in houses were found negative for parasites even though *Culex pipiens* Linnaeus taken at the same time showed many positives. With respect to *W. malayi*, Hu (1941) found that 1 out of 140 specimens fed on light cases developed infective filarial larvae. In another experiment 41 fed on a light case were negative, while 8 out of 13 *Anopheles sinensis* fed on the same case became infective; Hu stated that in view of the abundance of *subalbatus* in the lower Yangtze region it might play a minor part in transmission of *M. malayi*.

**12. *Aedes (Stegomyia) albopictus* (Skuse)—Figure 17.**

(For description and further notes, see pages 5 and 35.)

*Biology*.—On Okinawa and neighboring islands we found larvae commonly in artificial containers in dooryards. They were also abundant in tree holes in cemeteries and other places frequented by natives. A few collections were taken from rock holes and bamboos, and one from a taro axil. Adults were found resting in wooded areas, banana groves and sweetpotato patches. They bit readily in the shade during the day.

*Records*.—Abundant and widespread near villages from April to October: also collected on Ie, Hamahika, and Takabanare Islands.

*Relation to Disease*.—See discussion on dengue in the introduction and notes under *aegypti*.

**NOTES ON CONTROL**.—In areas where this species was abundant in artificial containers control was achieved by clean up of premises. The authors took part in several experiments in which DDT was applied by plane and in aerosol form from a ground machine. These tests gave only partial control of the larvae.

**13. *Aedes (Stegomyia) downsi* R. Bohart and Ingram.**

*Aedes downsi* R. Bohart and Ingram 1946. Jour. Wash. Acad. Sci. 36: 51  
(type locality: Chizuka, Okinawa).

*Female*.—Agreeing with description of *albopictus* (p. 5) except as follows: Scutum without a spot of silvery broad scales above wing base but with a few yellowish curved ones at this point. submedian posterior lines less sharply defined and with a yellowish tint. Hind femur mostly white in front on basal three-fifths, the white area not tapering to a point and well separated from small knee spot: hind tarsus with basal white bands covering about one-fifth of I, one-fourth of II, one-half of III, five-sixths of IV and all of V (except for a few dark apical scales in some specimens). Abdominal tergites I to VII with laterobasal (ventral) silvery spots, these not connected with basal bands which are usually present on II to VI and which are not broadened laterally; some specimens all dark in dorsal view or with incomplete bands.

*Male*.—Agreeing with description of *albopictus* except for scutal and leg differences given above and for the following points: Abdominal tergite VIII with a broad basal white band, other tergites dark in dorsal view or with weak basal bands on III to VI. Apical margin of ninth tergite sharply serrate, basal lobe of basistyle with bristles and leaflets all of about the same length.

*Larva* (description based on 18 paratypes collected on Okinawa from taro axils, cut bamboo and tree holes).—Agreeing with description of *albopictus* except as follows: Shoulder hair 1 with 3 to 5 branches, 2 single, 3 double to quadruple, 4 triple or quadruple, 5 and 6 single or double, 7 double or triple. Dorsal submedian hairs of abdomen usually with 5 to 7 strong branches (instead of 3 to 4 weaker branches in *albopictus*); 6 to 12 comb teeth: fifth pentad hair with 4 to 7 branches: 6 to 12 pecten teeth: siphon hair nearly always quadruple: lateral hair of anal segment double to quadruple, the longest branch usually reaching to or beyond apex of longer gill (not reaching beyond three-fourths in *albopictus*); gills broadly rounded apically, unequal, longer pair not more than twice anal ring and about 1.5 times as long as shorter pair.

*Biology.*—Larvae occur primarily in taro axils. In one wooded hillside locality near Shana Wan, where taros were abundant, we found them breeding also in tree holes, rock holes and cut bamboo. At Hedo larvae were collected in banana axils. In leaf axils they are associated with *Harpagomyia genurostris*, elsewhere with *Ae. riversi* and *Uranotaenia bimaculata*. Larvae were taken only during September but doubtless occur over a much longer period. Adults bite readily in the woods during the day.

*Distribution.*—Okinawa: Northwest coast, including Shana Wan, Chizuka and Hedo.

*Systematics.*—This species is a member of the *albopictus* group. Its relationship to *albopictus* and *flavopictus* Yamada were discussed by Bohart and Ingram (1946). The serrate ninth male tergite is similar in *flavopictus* and *downsi*, but the latter differs from both of the other species in the more restricted markings of the hind femora, the more extensively white hind tarsal IV and the fact that the abdominal bands, when present, do not widen laterally into spots.

*Relation to Disease.*—Unknown. Its biting habits bring it under suspicion.

**14. *Aedes (Stegomyia) riversi* R. Bohart and Ingram**—Figures 23, 64.

*Aedes riversi* R. Bohart and Ingram 1946. Jour. Wash. Acad. Sci. 36: 50  
(type locality: Chizuka, Okinawa).

*Female.*—Agreeing with description of *pseudoscutellaris* (p. 12) except as follows: Proboscis with a ventral line of pale scales. Abdominal tergites sometimes with incomplete to complete subbasal bands on V to VII.

*Male.*—Agreeing with description of *pseudoscutellaris* except as follows: Proboscis with a ventral line of pale scales. Abdominal tergite III often with a broken subbasal band, those on IV to VI often complete, VII with a dorsolateral subbasal spot, VIII largely white; some specimens without any complete bands on II to VI. Ninth tergite strongly but evenly convex apically; basal lobe of basistyle with 6 to 8 slender setae dorsally and assorted lengths of bristles (details best seen when lobe is separated from basistyle and mounted laterally).

*Larva* (description based on 26 paratypes collected on Okinawa from rock holes, tree holes, cut bamboo and artificial containers).—Agreeing with description of *albopictus* except as follows: 8 to 14 comb teeth of which an average number of 4 teeth are double to quadruple (in 24 paratypes), fringe extending at least half the shaft length of most comb teeth; 7 to 16 pecten teeth; siphon hair of 3 to 4 branches; gills nearly equal, longer pair at least twice as long as anal ring, sometimes very long, 14 paratypes having gills much longer than siphon.

*Biology.*—We found larvae most common in small rock holes, frequently in cut bamboo, occasionally in tree holes and rarely in artificial containers. Rock holes containing a few decaying leaves and berries seemed particularly favorable. Larvae were observed only in August and September, but probably occur at other times of the year. Adults rest among foliage and bite readily in the woods during the day.

*Distribution.*—Okinawa: Northwest portion including Shana Wan, Chizuka, and Hedo.

*Systematics.*—Externally this species is very similar to *zonatipes*. The

male genitalia are similar to those of *hensilli*, however, and the larval comb teeth are heavily fringed and often multiple. The gills of the larva are frequently very long, particularly in specimens from rock holes, but in some specimens they are only about two times as long as the anal ring.

*Relation to Disease*.—Unknown, but the biting habits bring it under suspicion.

**15. *Aedes (Stegomyia) aegypti* (Linnaeus)**—Figures 16, 65.

(For description and further notes, see pp. 6 and 35.)

*Biology*.—In Southern Okinawa we found larvae in dooryards in pottery crocks, cement cisterns, wooden buckets and metal drums.

*Records*.—The species has been recorded from various parts of the island by the Japanese (Anon., 1931). We made special efforts to find it, but we were unsuccessful except in southern Okinawa at Naha, Shuri, and Yonabaru. It was reported also from Shimabaru (C. T. Parsons).

*Relation to Disease*.—Japanese investigators considered it as more important than *albopictus* in the extensive dengue epidemic of 1931 on Okinawa (Anon., 1931). Its apparently limited distribution, according to recent surveys, should restrict its importance as a vector.

**16. *Aedes (Finlaya) togoi* (Theobald)**—Figures 31, 66.

*Culicelsa togoi* Theobald 1907. Monograph Culicidae 4: 379 (type locality: Osaka, Japan).

*Female*.—Length of wing 3.8 mm. Vertex with median area covered with black and white narrow curved and upright forked scales, white ones mostly toward middle and along eye margin: a large lateral spot of whitish broad appressed scales enclosing a dark spot of similar scales: palpus about one-fifth proboscis length, with numerous pale scales, particularly at tip: proboscis dark. Thoracic integument dark brown: scutum dark with an indefinite pattern of whitish scales consisting essentially of a rather double median line forking posteriorly, submedian anterior and posterior lines, and lateral patches; scutellum with narrow whitish scales only: apn with white broad scales: ppn with black and white broad appressed scales and sometimes a few white narrow ones: pleuron with patches of white scales: wing dark scaled: halter knob mostly pale: fore femur dark in front, a white line behind: mid and hind femur with an indistinct white basal line in front, mostly pale on basal two-thirds behind, mid femur with some pale scales also on apical one-third behind, knee spots present on all femora: tibiae dark except narrowly at base and apex: tarsi with a white basal band on I and bands covering the following joints, that covering IV-V weak on fore and mid tarsi. Abdominal tergites with weak basal white bands, broadening laterally: venter with narrow basal pale bands.

*Male*.—Palpus about four-fifths as long as proboscis, segments with pale basal bands. Basal lobe of basistyle expanded flange-like: claspette with a whip-like apical portion (fig. 31.)

*Larva* (description based on 10 specimens collected on Okinawa).—Antenna with a double to quadruple tuft at middle which falls short of apex, shaft spiculate: clypeal spine very slender and long: head hair *A* with about 8 branches, *B*, *C* and *d* in a line near front of head, many branched, *d* small: mentum with 33 to 35 teeth. Shoulder hairs fairly

weak. 1 and 3 double to triple. 2 and 6 single. 4 double. 5 and 7 triple or quadruple. Comb of 60 to 80 apically fringed teeth in a patch; first to fifth pentad hairs with about 1. 1. 11. 1 and 5 branches respectively. first pentad often split; siphon hardly twice its basal diameter; acus large; pecten of 17 to 22 teeth along basal two-thirds of tube. teeth with minute lateral denticles; subventral siphon tuft of 8 to 10 branches inserted near apical one-fourth of tube; anal segment large. with a small dorsal sclerotized plate which has small spicules posteriorly; lateral hair of anal segment single and strong. inserted outside plate; gills globular; about 13 anal brushes; osc single, isc many branched.

*Biology.* Larvae breed in fresh to highly saline water near the sea-coast. We found it in the following situations: Fresh water in a crock and a cement fish pool; fresh and brackish water in large concrete cisterns in a tidal flat area; in shaded coral rock pools with brackish water; and in open. warm. highly saline rock pools. The larvae were observed to stay under several feet of water for many minutes when disturbed. We did not observe adults in nature but Feng (1933) recorded the species as a serious pest along the coast in China. entering houses at night to bite.

*Distribution.*—East coast of Siberia. Japan. China. Ryukyus. and Iwo Island. The Japanese recorded the species as rather common and widespread on Okinawa (Anon., 1931). We found it at Naha. Shimabaru. Bolo Point. and Kin. We have seen specimens also from Ie Island.

*Systematics.* This species does not appear to be closely related to any other species of *Finlaya*. The larva is particularly distinctive with respect to the siphon and globular gills (fig. 31). The pattern of the scutum is definitely linear in some specimens. especially newly emerged females. but in others it may appear rather patchy.

*Relation to Disease.*—There are numerous reports in the literature on the ability of this species to carry *Wuchereria bancrofti*. Mochizuki (Yamada. 1927) dissected specimens of *togoi* 15 to 16 days after feeding and found 38 of 39 larvae fully developed. Yamada (1927) fed 20 females on an infective case. and 12 to 18 days later he dissected 178 filarial worms from 14 of them. Of the 178 worms. 171 had completed their growth and 19 of these were in the mouthparts of the mosquitoes. It appears that where *togoi* is locally abundant it is a good potential vector of *W. bancrofti*.

Chagin and Kondratiev (1943) reported *togoi* as a vector of Japanese "B" encephalitis in the Soviet Far East. but they indicated that its localized distribution made it less important than *Culex tritaeniorhynchus*. *C. bitaeniorhynchus* and *Aedes esoensis* Yamada.

#### 17. *Aedes (Finlaya) okinawanus* R. Bohart—Figures 32, 67.

*Aedes okinawanus* R. Bohart 1946. Proc. Biol. Soc. Wash. 59: 39 (type locality: Okuma, Okinawa).

*Female.*—Length of wing 3.00 mm. Median area of vertex with pale lemon yellow. narrow curved and upright forked scales. flanked by a large spot of black broad appressed scales and a lateral spot of broad appressed creamy ones which encloses a black dot; eyes bordered inwardly with yellow narrow scales; palpus and proboscis black; palpus about one-fifth as long as proboscis. Scutum with distinct narrow lines of lemon yellow consisting of a median line forking posteriorly. a submedian anterior line. a line around anterior margin of scutum bowing inward along fossal

area and continuing to posterior margin as a sublateral line, a few pale scales over wing base (fig. 32); scutellum with black broad appressed scales on mid lobe and with black and yellow narrow curved scales on all lobes; anterior pronotal lobe with whitish broad appressed scales; preepimeron with whitish broadly crescent-shaped scales; pleuron dark brown with several large patches of whitish broad appressed scales; wing dark scaled; halter knob with dark and dull pale scales; fore and mid femora with a broad pale line on hind surface, hind femur pale on five-sixths of posterior surface, dark along whole length dorsally, pale on basal two-thirds in front, a restricted knee spot on hind femur, indistinct on other femora; tibiae mostly dark; fore tarsal I sometimes with a few basal pale scales, tarsus otherwise dark; mid and hind tarsi pale at base of I, hind tarsus also with pale joint marks over first 3 joints and with V entirely dull pale above.

*Male*.—About as in female except for hind tarsi. Palpus all dark and about two-thirds as long as proboscis, last segment about as long as its apical bristles. Scutal lines usually pale lemon yellow. Tarsal markings weaker than in female, fore tarsus all dark, hind tarsal V all dark. Genitalia as in figure 32.

*Larva* (description based on 10 specimens collected on Okinawa from tree holes).—Antenna slender and sparsely spiculate, with a single hair near middle reaching to apex of shaft; clypeal spine very slender; head hair *A* with 8 to 10 branches; *B* single and very long; *C* slightly posterior and close to *B*, with 4 or 5 branches about half as long as *B*; *d* on a line with *B*, small and multiple; mentum with about 19 sharp teeth. Shoulder hair 1 double or triple, 2 and 6 single, 3 with 4 or 5 branches, 4 triple or quadruple, 5 and 7 very long, plumose and triple. Comb of about 60 apically fringed teeth in a patch; second and third pentad hairs with 3 to 5 branches, fourth pentad usually double, fifth pentad with 4 to 8 branches; siphon 3.5 to 4.0 times its basal diameter; acus present; pecten of 22 to 26 teeth of which last 10 are about equal in size, pecten on basal half of tube, tuft of 5 to 7 plumose branches inserted at apical two-fifths of tube; anal segment with a two-thirds complete ring which is posteriorly spiculate and which bears a single, short, apically frayed hair; gills pointed, unequal, longer pair about as long as anal ring and twice as long as shorter pair; fan of 10 hair brushes, all in barred area; osc single, isc triple.

*Biology*.—Larvae of this species occur most often in tree holes where it is the dominant Okinawan *Aedes* in areas removed from habitations. In and around villages its place is largely taken by *Ae. albopictus*. We took larvae from May to October, 1945, and in addition to tree holes, occasional breeding places were artificial containers and cut bamboo. Adults bite readily in deep shade during the day and are moderately persistent. They rest in vegetation or sometimes on damp rocks.

*Distribution*.—Okinawa: Northern half of the island including Nago, Kochiya, Shana Wan, Chizuka, Okuma, Hentona, and Uka.

*Systematics*.—According to Bohart (1946b), this species is most closely related to *aureostriatus* (Doleschall) which also has all dark palpus and a similar scutal pattern. The Okinawa species differs in the all yellow upright vertex scales, all dark last hind tarsal in the male and slightly different male genitalia (fig. 32). The larva has a somewhat shorter

siphon than in *aureostriatus*, but the peculiar head hair arrangement seems identical in the 2 species (fig. 32).

*Relation to Disease*.—Unknown. Its biting habits bring it under suspicion, however.

**18. *Aedes (Finlaya) sp. in gubernatoris group*—Figure 29.**

*Adult*.—Unknown. Other members of the group have a small to large patch of white scales on the scutum in front, and an all dark palpus. The hind tarsus has one or more segments with joint bands but the last two or three segments are all dark.

*Larva* (description based on 2 specimens collected on Okinawa from cut bamboo).—Antenna not spiculate, a single to triple hair at apical one-third, reaching about to apex of shaft; clypeal spine pale, stout and blunt; head hair *A* small and double or triple, *B* single or split at middle, *C* single, *d* with 4 or 5 branches and placed halfway between *B* and *C*; mentum with about 15 teeth. Shoulder hairs 1 to 3 short and stout, inserted on a plate, 1, 2, 5 and 6 single, 3 double to quadruple, 4 and 7 usually double. Comb of about 50 apically fringed teeth in a patch: first and fifth pentad hairs triple or quadruple, third pentad with 6 or 7 branches; siphon about 2.5 times its basal diameter, dark brown with a yellowish apical ring, a small acus, pecten of about 18 teeth with subbasal denticles, occupying basal half of tube and followed by a stout hair of 7 or 8 branches; anal segment about two-thirds ringed, with small posterior spicules; lateral hair stout, short and single to triple; gills shorter than anal ring; about 10 anal brushes, last 2 or 3 small and anterior to barred area; osc single, isc triple to quadruple.

*Biology*.—We found 2<sup>+</sup> larvae of this species among many hundreds of *Aedes riversi* and *Ae. downsi* collected from cut bamboo. Adults were not reared.

*Distribution*.—Shana Wan, Okinawa.

*Systematics*.—The larva agrees closely with that of *jeegradei* Barraud (1934) from Rangoon, Burma, even to such details as the blunt clypeal spines and exact arrangement of the head hairs.

**19. *Aedes (Aedimorphus) vexans nipponii* (Theobald)—Figure 34.**

*Culicada nipponii* Theobald 1907. Monograph Culicidae 4: 337 (type locality: Karnizana, Japan).

*Ochlerotatus vexans nipponii* of Edwards 1917. Bul. Ent. Res. 7:219.

*Adult*.—Agreeing with description of *vexans nocturnus* (p. 15) except for abdominal tergites which commonly have median apical pale markings on II to VII, these marks usually extending anteriorly so as to form a broken stripe down middle of abdomen (stripe broken at emargination of basal bands).

*Larva* (description based on 10 specimens collected on Okinawa from ground pools).—Agreeing with description of *vexans nocturnus* except as follows: Head hair *B* usually double, rarely single; *C* usually triple, rarely double or quadruple. Siphon 3.5 to 5.0 times its basal diameter.

*Biology*.—We collected larvae on 5 occasions in April and May, 1945 in temporary ground pools filled with rainwater. Except for one collection in an open foxhole, the water was partially shaded and contained leaves. In each case *C. quinquefasciatus* was associated.

*Distribution.* Northern Oriental Region, southeastern Palearctic Region. We found it at Miyazato, Jaba, Kadena and China, all in south central Okinawa.

*Relation to Disease.*—The uncommon and erratic occurrence of this mosquito indicates that it is of little potential importance as a vector on Okinawa.

**20. *Culex (Lutzia) vorax* Edwards—Figure 35.**

*Culex vorax* Edwards 1921. Bul. Ent. Res. 12: 327 (type locality: Tokyo, Japan).

*Female.*—Length of wing 5.5 mm. Vertex with broad median area covered with creamy narrow curved scales and many dark upright forked ones, a small lateral patch of creamy broad appressed scales; palpus and proboscis speckled with pale scales, those on latter concentrated into a very broad but poorly defined median band. Scutal integument evenly brown with hairlike pale brownish and a few creamy scales; scutellum with creamy narrow curved scales; pronotal lobes with some narrow curved and broader pale scales; pleuron brown with about four patches of dull pale scales, four to six lower mesepimeral bristles; wing and halter knob dark scaled; femora spotted and speckled with creamy scales; fore and mid tibia with a row of spots, those on hind tibia more or less coalesced; tarsi pale brown, unbanded. Abdominal tergites II to VII with apical yellow bands of about equal width and with laterobasal (ventral) pale areas; venter mostly pale.

*Male.* Palpus longer than proboscis by slightly more than last segment; last two segments with some pale basal scales above and below, first long segment with a row of pale scales beneath; terminal segment with mostly pale integument. Proboscis darker, with a fairly definite narrow subapical pale band at which point proboscis is constricted into pseudojoint. Abdominal segment VIII pale above. Lateral plate of mesosome pointed and with a toothed median process (fig. 35).

*Larva* (description based on six specimens collected on Okinawa from ground pools).—Antenna smooth, with a small single hair near basal one-third; mouth brushes very strong; clypeal spine hairlike; head hairs placed well back on head. *A*, *B*, and *C* long and single, *d* in front of *B* and split into 3 to 5 branches; mentum with 9 large teeth. Shoulder hairs 1 to 7 all single and on plates. Comb of about 50 apically fringed or spined teeth in a patch; third pentad hair with 9 to 12 branches, other pentads single except fifth which is stout and rarely double; siphon about 1.6 times its basal diameter, with a ventral row of about 14 hairs associated with 11 or 12 pecten teeth for whole length of tube; a subventral single to triple hair at apical two-thirds; one or more apical pecten teeth simple and very stout; siphon and anal segment covered with minute spicules; anal segment completely ringed, twice as long dorsally as ventrally, lateral hair single; gills very small, about equal; about 13 hair brushes in barred area; osc and isc single.

*Biology.*—Larvae occur in artificial containers or ground pools, and rarely in rock holes. They are predaceous on the larvae of other mosquitoes as well as those of some other insects such as chironomids (bloodworms). Their chief prey is *C. quinquefasciatus*. Adults rest on damp rocks and among low-growing vegetation. They will feed on man, but are not

persistent. Feng (1938) reported that adults were induced to feed in the laboratory, but were not observed to bite man in nature.

*Distribution.*—India, Burma, China, Iwo L., and Japan. We found it widely distributed on Okinawa, but in moderate numbers. It was collected also on Iheya Island (G. F. Augustson).

*Systematics.*—Four species of *Lutzia* are known in the Orient. They are all large, have similar habits and the larvae are apparently indistinguishable. The adults differ in rather minor characters, principally in abdominal markings. *C. vorax* is the only one to have pale apical bands of about the same width on the abdominal tergites.

*Relation to Disease.*—Hu (1939) reported that 21 of 29 mosquitoes fed on a heavy infection of *W. bancrofti* developed infective filarial larvae. Hu (1941) fed 18 *vorax* on a heavy infection of *W. malayi* and recorded development to the infective stage in 4 of these. Each contained only a single larva, however while *Anopheles sinensis* fed at the same time developed many infective larvae. In view of the feeding habits of *vorax*, it is not likely to be an important vector.

**21. *Culex (Neoculex) hayashii* Yamada**—Figures 36, 56.

*Culex hayashii* Yamada 1917. Dobutsugaku-Zasshi 29: 68 (type locality: Tokyo, Japan).

*Culex hayashi* of Edwards 1921. Bul. Ent. Res. 12: 336.

*Female.*—Length of wing 2.8 mm. Vertex with broad median area covered with gray to ochreous narrow curved and pale brown upright forked scales, pale broad appressed scales laterally; palpus and proboscis dark, latter about seven times as long as former. Scutal integument brown covered with bronzy hairlike scales; scutellum with somewhat paler narrow scales; apn bare of scales or with a few hairlike ones; pleuron without scales, one lower mesepimeral bristle; wing and halter knob dark scaled; legs dark, except on femora behind. Abdominal tergites all dark, scales somewhat opalescent.

*Male.*—Palpus slender, about two-thirds to three-fourths as long as proboscis, last segment with long bristles. Genitalia as in figures.

*Larva* (description based on 14 specimens collected on Okinawa from small streams and rock pools).—Antenna constricted and tufted at apical one-third, dark at base and beyond tuft, shaft spiculate, subapical bristles inserted well before apex, these very long, strong and dark, far surpassing apical ones; clypeal spine strong and dark; head hair *A* with about 5 branches, *B* longer than *C* and single to triple, *C* single or double, neither *B* nor *C* reaching front of head, *d* very small, double or triple, placed in front of *B*; mentum with 15 to 17 teeth. Shoulder hairs 1, 2, 5 and 6 very long and single, 3 shorter and single, 4 short and single or double, 7 moderate and double. Comb of about 55 apically fringed teeth in a patch: first to fifth pentad hairs usually with 5, 1, 7, 1, and 2 branches respectively; siphon about 6.5 times its basal diameter, apical one-half parallel-sided, 11 or 12 laterally fringed and dentate pecten teeth on basal one-third of tube, 6 or rarely 7 pairs of moderate subventral tufts along apical three-fifths of tube, specimens from dark water usually with a dark median spot and apical band (as in *C. infantulus*); anal segment with a complete ring which is not spiculate posteriorly and which bears a small, single, apically frayed hair; gills about equal, pointed and shorter

than anal ring: about 14 anal hair brushes of which 1 or 2 are usually very small and anterior to barred area; osc single, isc triple.

*Egg* (described from an egg mass deposited in the laboratory by a specimen taken from a damp rock, Chizuka, Okinawa).—About 75 eggs in a circular mass. Egg 0.7 mm. long, uniformly dark gray, slightly granular but not reticulate, somewhat curved in lateral view with a slight but distinct boss at basal two-fifths (fig. 56).

*Biology*.—We made numerous collections of larvae in rock pools or side pools of small streams. Occasionally, they occurred in seepage pools. Associated larvae in different collections were *C. bitaeniorhynchus*, *C. infantulus*, *C. tritaeniorhynchus* and *Anopheles sinensis*. Larvae from dark water usually exhibited a dark median ring on the siphon, as in many *infantulus*. Adults were collected resting in damp situations among vegetation and rocks. They did not attempt to bite. Two gravid females deposited egg rafts on damp filter paper in the laboratory.

*Distribution*.—Japan, China, Ryukyus. We found it in fair abundance on the northern half of Okinawa at Kochiya, Nago area (4 mi. east of Nago), Genka, Hentona, and Hedo.

*Systematics*.—This species is similar to *tenuipalpis* Barraud but differs in having the male palpus two-thirds to three-fourths as long as the proboscis, instead of one-half. Larvae of the two species appear to be very similar but according to the figures of Barraud (1934), the gills of *tenuipalpis* are much longer than the anal ring and the pecten teeth have smaller denticles on the apical one-half.

## 22. *Culex (Neoculex) brevipalpis* (Giles)—Figure 37.

*Stegomyia brevipalpis* Giles 1902. Handbook of gnats or mosquitoes, 2d ed. p. 384 (type locality: Shahajahanpur, India).

*Female*.—Length of wing 2.7 mm. Broad median area of vertex covered with bronzy scimitar-shaped scales, pale along eye margin, many light brown upright forked scales, a lateral patch of pale broad appressed scales; palpus and proboscis dark, latter about six times as long as former. Scutal integument dark except narrowly at side, scales dark except at front margin; scutellum with narrow curved dark scales; apn with a few narrow pale scales; ppn without scales; pleuron pale green or pale ochreous with a few scattered scales, particularly along hind margin of sternopleuron, no lower mesepimeral bristle; wing and halter knob dark scaled; legs long and stout, dark with a bronzy sheen, femora pale behind. Abdominal tergites dark with a bronzy sheen.

*Male*.—Palpus somewhat more than half as long as proboscis, usually appearing twisted; subterminal segment enlarged, bowed outward and with some short apical bristles; terminal segment short and with some short stout apical bristles.

*Larva* (description based on 3 specimens collected on Okinawa from a tree hole).—Antenna constricted and tufted at apical one-fourth or one-fifth, shaft spiculate, apical and subapical bristles inserted close together and nearly the same length; clypeal spine strong and dark; head hair *A* with 5 or 6 branches, *B* and *C* double, surpassing front margin of head, *d* single and in front of *B*; mentum of about 17 teeth of which middle one is very broad. Shoulder hairs all moderately long, 4 and 7 double, others single. Lateral abdominal hairs of III to VI long and double. Comb

of about 50 apically fringed teeth in a tight patch; first to fifth pentad hairs usually with 5, 1, 6, 1 and 1 branches respectively; siphon about 12 times its basal diameter, apical three-fourths parallel-sided; 14 or 15 laterally dentate pecten teeth along basal one-fifth of tube; 4 or 5 minute multiple subventral hairs scattered along tube; anal segment with a complete sclerotized ring which is not spiculate posteriorly and which bears a small, single, apically frayed hair; gills unequal, bluntly pointed, longer pair about as long as anal ring; 10 hair brushes in barred area; osc and isc long and single.

*Biology.* The larvae occur in tree holes, bamboos and occasionally in artificial containers (Barraud, 1934). We made a single larval collection from a deep tree hole.

*Distribution.*—Widely distributed in the Oriental region. On Okinawa we found it in a densely forested area near Shana Wan. It was collected also at Nakasoni (J. B. Duncan).

*Systematics.* The dark scutum, pale pleuron and twisted male palpus are characteristic. The larval siphon is longer than in any other species on Okinawa.

**23. *Culex (Lophoceraomyia) infantulus* Edwards**—Figures 38, 54, 70.

*Culex infantulus* Edwards 1922. Ind. Jour. Med. Res. 10: 287 (type locality: Hong Kong, China).

*Female.*—Length of wing 3.0 mm. Broad median area of vertex covered with yellowish narrow curved scales and brownish upright forked ones, a line of small pale broad appressed scales along eye margin; palpus and proboscis dark, latter about six times as long as former. Thoracic integument rather uniformly brownish or greenish; scutal scales bronzy, paler in front; scutellum with light brown scales; apn and ppn apparently without scales; pleuron with a few scales scattered along posterior margin of sternopleuron<sup>12</sup>, one lower mesepimeral bristle; wing and halter knob dark scaled; legs dark, femora pale behind. Abdominal tergites with narrow basal dull pale bands, at least on IV to VI.

*Male.*—Antenna with some short specialized setae on VIII (torus counted as I) and a group of longer matted setae on IX, torus without an inner knob. Palpus slender, longer than proboscis by most of last segment. Genitalia remarkable for placoid structure of mesosomal process (fig. 38).

*Larva* (description based on 10 specimens collected on Okinawa from a small stream pool and from rock pools).—Antenna constricted and tufted at apical one-third, dark at base and beyond tuft, shaft spiculate, subapical and apical bristles well separated at base, former strong and dark, slightly surpassing latter; clypeal spine strong and dark; head hair *A* with about 6 branches, *B* and *C* double and extending beyond front of head, *d* small and single, placed in front of *B*; mentum with about 19 teeth. Shoulder hair 3 single or double, 4 double, 7 triple or quadruple, 1, 2, 5 and 6 single. Lateral abdominal hairs of III to VI strong and triple or quadruple. Comb of about 50 teeth in a patch; first to fifth pentad hairs with about 4, 1, 7, 1 and 4 branches respectively; siphon about 10 times its basal diameter, apical one-half parallel-sided, a dark basal band and a broad median band usually present, 12 to 15 pecten

<sup>12</sup>These scales are present on all *Lophoceraomyia* as far as we have been able to determine. They are overlooked in most original descriptions.

teeth on basal two-sevenths of tube; 4 lateroventral double siphon hairs which are shorter than basal diameter of tube; anal segment with a complete ring which is not spiculate posteriorly and which bears a short double to quadruple hair; gills equal, pointed and shorter than anal ring; 12 hair brushes in barred area; osc single, isc triple or quadruple.

*Egg* (described from an egg mass deposited in the laboratory by a specimen taken from a damp rock, Chizuka, Okinawa).—About 70 eggs in a circular mass. Egg 0.7 mm. long, uniformly dark gray, slightly curved in lateral view (fig. 54).

*Biology*.—We occasionally found larvae from May through September in seepage pools, stream pools with much vegetation and rock pools. They were sometimes associated with *C. hayashii*. Adults were collected resting on damp vegetation and rocks along streams. They were not observed to bite. A gravid female deposited an egg raft on damp filter paper in the laboratory.

*Distribution*.—Siam, China, Philippines, Ryukyus, and Japan. Okinawa records are in the northwestern section only, from Nago, mountains 4 miles east of Nago, Nakasoni, Chizuka and Hedo.

*Systematics*.—This species is easily recognized in the male by the comparatively simple antenna and the peculiar mesosome. The latter consists (on each side) of a stout base bearing a fleshly appendage covered with irregular plates (fig. 38). The larva appears to be practically identical to that of *minutissimus* (Theobald) from India and the Dutch East Indies. The dark basal and median siphonal bands are useful for quick identification but they are not always present.

**24. *Culex (Lophoceraomyia) tuberis* R. Bohart—Figure 39.**

*Culex tuberis* R. Bohart 1946. Proc. Biol. Soc. Wash. 59: 42 (type locality: Chizuka, Okinawa).

*Female*.—Unknown.

*Male*.—Length of wing 2.5 mm. Vertex covered with pale narrow curved and dark upright forked scales in broad median area, laterally with a large spot of pale broad appressed scales continued inward along eye margin; torus with a large knob at upper inner angle; flagellum with specialized setae on segments VI to X (torus considered as segment I): VI with about six yellowish setae of varying lengths; VII to IX with matted and twisted tufts, shortest on VIII; X with six slender setae (fig. 39); mouthparts dark; palpus longer than proboscis by about length of last segment, last two segments not very hairy, no row of stiff hairs at base of proboscis. Scutal integument pale brown with indistinct submedian dark lines and hairlike brown scales; pleuron almost uniformly pale brown with a few scattered scales, most evident along lower hind margin of sternopleuron, no lower mesepimeral bristle; wing scales and halter knob dark; femora pale-lined beneath; tibiae and tarsi dark. Abdominal tergites dark scaled; distal division of subapical lobe of basistyle greatly elongated and hairy, bearing at its base a long blade and at its apex two short curved setae and a short blade of distinctive shape; inner margin of basistyle with a row of six or seven long curved bristles.

*Larva* (described from a single specimen).—Antenna tufted and constricted at apical two-thirds, darkened at extreme base and slightly

beyond tuft, subapical bristles slightly longer than apical long one; clypeal spine fairly stout and black; head hair *A* with 6 branches, *B* and *C* double, *d* single and slightly in front of *C*; mentum with 17 teeth. Shoulder hairs 1, 2, 3, 4 and 5 single, 4 and 8 double, 7 triple. Lateral abdominal hairs strong and triple or quadruple on III to VI. Comb of about 50 apically fringed teeth in a patch: first to fifth pentad hairs with 5, 1, 8, 1 and 4 branches respectively; siphon gently but distinctly upcurved, about 10 times its basal diameter, with 4 pairs of sublateral double hairs which are about as long as subapical diameter of tube, 17 pecten teeth, each with about 7 denticles; anal ring with a small double hair; gills pointed and about equal, a little longer than anal ring; 12 hair brushes in barred area; osc single, isc triple.

*Biology*.—Adults were reared from rock holes along a stream and from a seepage pool.

*Distribution*.—Okinawa: Northwest coast at Chizuka and Genka.

*Systematics*.—This species falls in the group of *Lophoceraomyia* in which there is a knob on the torus of the male. It differs from many other species of the group by its pale brown thoracic integument and from all others described by the elongate hairy distal division of the subapical lobe of the basistyle (fig. 39).

**25. *Culex (Culiciomyia) pallidothorax* Theobald**—Figures 42, 55.

*Culex pallidothorax* Theobald 1905. Jour. Econ. Biol. 1: 32 (type locality: India).

*Female*.—Length of wing 3.8 mm. Broad median area of vertex covered with light brown to pale narrowed curved scales and dark to brownish upright forked ones, paler scales toward eye which is margined with pale broad appressed scales, a lateral spot of pale broad appressed scales; palpus and proboscis dark, latter about five times as long as former. Scutal integument pale brown or greenish with ochreous to light brown scales, paler in front; scutellum with ochreous to pale, narrow scales; apn and ppn with some ochreous narrow scales; pleuron without scales, greenish or pale brown with a usually well developed dark stripe from apn to beneath wing base, another shorter stripe starting at anterior corner of sternopleuron (fig. 42), one lower mesepimeral bristle; wing and halter knob dark scaled, anterior fork cell more than twice length of its stem. Abdominal tergites with dull pale basal bands which have straight or somewhat convex hind margins.

*Male*.—Palpus longer than proboscis by length of last segment, last two segments with many long hairs. Dististyle with a serrate crest.

*Larva* (description based on 10 specimens from Okinawa).—Antenna tufted shortly before middle, sparsely spiculate, subapical bristles not extending beyond apical ones; clypeal spine pale and slender; head hair *A* with 6 or 7 branches, *B* double to quadruple, *C* double or triple, *B* and *C* reaching about to front margin of head, *d* single and placed well in front of *B*; mentum with about 31 teeth. Shoulder hair 1 double, 2, 5 and 6 single, 3, 4 and 7 double or triple. Lateral abdominal hairs on III to VII long and single or occasionally double. Comb of about 40 apically fringed teeth in a patch: first pentad hair with 5 to 9 branches, second to fifth pentads usually with 1, 8, 1 and 2 branches respectively; siphon swollen toward middle, very narrow at apex, about 5.0 times its basal diameter

but only 3.5 times its greatest diameter; pecten of 4 to 9 rather widely and irregularly spaced teeth on basal one-third of tube, each tooth with 3 or 4 denticles; siphon with 4 or rarely 5 subventral hairs with 2 to 6 branches which are about half as long as basal diameter of tube; anal segment with a complete sclerotized ring which has small posterior spicules and which bears a moderate double to quadruple hair; gills nearly equal, stout and pointed, longer pair about twice as long as anal ring; 8 to 10 anal brushes in barred area; osc and isc single.

*Egg* (described from an egg mass deposited in the laboratory by a specimen collected from a damp rock, Chizuka, Okinawa).—About 100 eggs in a circular mass. Egg 0.8 mm. long, uniformly gray, almost straight in lateral view (fig. 55).

*Biology*.—Barraud (1934) records the breeding places as "tree-holes, bamboos, shallow wells, stream and rock-pools, swampy ground-pools, sometimes in foul water." On Okinawa we found them only in artificial containers, ground pools (polluted) and rock pools (rarely). In domestic situations they were usually associated with *C. quinquefasciatus* and in the woods sometimes with *C. ryukyensis*. Adults were commonly collected in caves and occasionally were found in houses or clinging to damp rocks in the woods. A gravid female collected in the field deposited a circular mass of eggs on damp filter paper in the laboratory. We did not observe adults attempting to bite, and Feng (1938) stated that adults could not be induced to feed on human blood in the laboratory. However, Hu (1940a) succeeded in feeding 6 of 84 females on a filarial patient (see below).

*Distribution*.—India, Malay Peninsula, Siam, Cochin China, Moluccas, China, and the Ryukyus. On Okinawa we found it only in the north, from Nago, Taira, Chizuka, Hentona, Nakaoshi, and Kochiya. Records are also from adjacent islands of Ie, Heanza, Takabanare, and Hamahika.

*Systematics*.—It can be recognized by the dark stripe across the upper pleural region, the long and hairy male palpus, the spiny crest of the dististyle and the rather light brown color of the scutal scales. The sub-apical lobe of the style bears about 10 stout setae in addition to the two usual apical setae and two broad ventrally inserted processes (fig. 42). These structures occur in Indian specimens which we have examined but they were not all shown in the figure of Barraud (1934). The larval siphon is characteristically swollen toward the middle and narrowed apically (fig. 42).

*Relation to Disease*.—Hu (1940a) subjected 84 female *pallidothorax* to starvation for 1 to 2 days and induced 6 of them to engorge on a filarial case. Upon dissection 22 to 23 days later, 5 of the specimens contained infective larvae of *W. bancrofti*. Hu concluded that *pallidothorax* was a potential vector but that its disinclination to bite man and its rarity in the Shanghai area argued against its importance there.

**26. *Culex (Culiciomyia) ryukyensis* R. Bohart—Figure 41.**

*Culex ryukyensis* R. Bohart 1946. Proc. Biol. Soc. Wash. 59: 41 (type locality: Chizuka, Okinawa).

*Female*.—Length of wing 2.5 mm. Broad median area of vertex covered with yellowish white narrow curved scales and brown upright forked ones, vertex laterally with a spot of dull whitish broad appressed scales

continued inward along eye margin; mouth parts dark; palpus about three times as long as clypeus and one-fifth proboscis length. Scutum brown scaled, pleuron without scales, pale green or pale brown, with a faint dark stripe from apn to upper part of mesepimeron, a small dark spot at anterior corner of sternopleuron; one lower mesepimeral bristle; wing scales dark; femora pale beneath, legs otherwise dark. Abdominal tergites with dull pale straight margined basal bands on II to VII.

*Male.* Palpus longer than proboscis by one-fourth to one-third of last segment, last two segments sparsely haired. Subapical lobe of basistyle with two black rods which are visible in pinned specimens; dististyle appendage inconspicuous; lateral arm of paraproct elongate but not enlarged.

*Larva* (description based on 10 paratypes from Okinawa).—Antenna tufted shortly before middle, tuft not quite reaching to apex of shaft which is finely spiculate and not much darkened, insertions of apical and subapical bristles well separated; clypeal spine slender and pale brown; head hair *A* with about 7 branches, *B* and *C* triple, reaching shortly beyond clypeus, *d* simple, well in front of *C*; mentum with about 27 teeth. Shoulder hairs reaching about to middle of head; 1, 4, 7 and 8 double, 2, 5 and 6 single, 3 single or double. Comb of about 55 apically fringed teeth in a patch; third pentad with about 7 branches, fifth pentad double or rarely single; siphon about 6 times its basal diameter, tapering gradually to a narrow and somewhat upcurved apex, with 3 pairs of small sublateral double hairs along apical two-fifths of tube; pecten of 14 to 20 teeth, each with 3 or 4 lateral denticles; anal segment with a complete ring which is posteriorly spiculate and which bears a short single hair; gills unequal, shorter pair twice as long as anal ring; fan of 8 hair brushes in barred area; osc and isc single.

*Biology.*—Larvae were collected commonly from May through September in rock holes or artificial containers along streams. Larvae with which they were most frequently associated were *C. pallidothorax* and *Ae. riversi*. Adults were found resting on damp rocks along streams. They were not observed to bite.

*Distribution.*—We found the species only in the northern half of Okinawa, where it is moderately abundant in secluded places. Locality records are Kochiya, Yabu, Nakasoni, Chizuka, Hentona, and Hedo.

*Systematics.*—According to Bohart (1946b), the species is most closely related to *bailyi* Barraud which also has reduced pleural markings and an uncrested dististyle. It differs from *bailyi*, however, in the structure of the subapical lobe of the basistyle and in the shorter male palpus.

## 27. *Culex (Culex) bitaeniorhynchus* Giles—Figure 43.

*Culex bitaeniorhynchus* Giles 1901. Jour. Bombay Nat. Hist. Soc. 13: 607 (type locality: Travancore, India).

*Female.*—Length of wing 4.5 mm. Broad median area of vertex covered with yellowish narrow curved and brownish yellow upright forked scales, a lateral spot of dull pale, broad appressed scales; palpus narrowly pale at tip; proboscis with a median band covering about one-fourth of surface, a few apical pale scales. Scutal integument dark, covered with golden brown to ochreous and some dark scales in front of wing bases, scales mostly dark on posterior one-fifth of scutum; scutellum dark scaled at

base of mid lobe, golden scaled at apex and on lateral lobe; apn and ppn with narrow curved scales which are mostly yellowish, pleuron rather uniformly brown or dull green except for dark spiracular area, with 2 patches of pale scales on sternopleuron; no lower mesepimeral bristles; wing speckled with yellowish scales, some of which are fairly broad; halter knob with yellowish scales; femora and tibiae speckled, mid and hind femora mostly pale behind; tarsi with base of I yellow and with narrow yellowish bands covering the joints. Abdominal tergites with rather broad apical yellowish bands and some scattered yellowish scales, tergite VIII all yellow.

*Male*.—Palpus longer than proboscis by most of last two segments, long segment with two pale bands, last two segments with basal pale bands, last segment with apical two-fifths pale. Proboscis with band just beyond middle and covering about one-sixth of surface. Basal arm of paraproct small.

*Larva* (description based on 10 specimens collected on Okinawa from rice paddies and algal pools).—Antenna tufted and constricted at middle, shaft minutely spiculate, subapical bristles inserted near apex and not surpassing long apical bristle; clypeal spine long, stout and pale; head hair *A* with 4 to 6 branches, *B* usually double, *C* usually triple, *B* and *C* rather short but surpassing apex of head, *d* very small and single, slightly in front of *B*; mentum triangular, with about 100 minute teeth. Shoulder hairs 1 to 3 on a prominent tubercle, all hairs long and single except 4 which is sometimes double and 7 which is double or triple. Comb of 4 to 6 strong teeth in an irregular row; first to fifth pentad hairs usually with 4 (or 5), 2, 6, 2 (or 3) and 3 (or 4) branches respectively; siphon about 6 to 8 times its basal diameter, parallel-sided along apical one-half; with 6 to 8 minute pale pecten teeth at extreme base of tube; with 6 to 8 ventral, double or triple hairs, sometimes arranged in 3 or 4 pairs, the tufts shorter than basal diameter of tube; apical dorsal bristle strong and black, half as long as diameter of tube at point of insertion; anal segment with a complete sclerotized ring which is not spiculate posteriorly and which bears a small and split lateral hair; gills equal, pointed, 1.5 to 2.0 times as long as anal ring; 12 anal brushes in barred area; osc single, isc double to quadruple.

*Biology*. Larvae occur commonly in rice paddies and ponds, particularly in association with green algae. We found them frequently in algal pools of streams. They seem to prefer relatively clean water. The most commonly associated species on Okinawa is *Anopheles sinensis*. Adults rest in low-growing vegetation, in caves, and on damp rocks. They sometimes enter houses at night to bite, but they do not seem to be serious pests. According to Feng (1938), the females in China will feed occasionally during the day as well as at night and they are frequently found in houses situated near dense breeding areas. The eggs are laid in crescentic masses which we saw commonly in rice paddies on Okinawa.

*Distribution*.—Africa, Oriental region, Japan, New Guinea, Soviet Far East, and northern Australia. We found it everywhere on Okinawa in open water of streams, ponds, and rice paddies. Specimens were collected also on Takabanare Island.

*Systematics*. A large species characterized by the speckled wings, banded proboscis and apical yellow bands on the abdominal tergites. The larva resembles that of *sinensis* but is easily distinguished by the position of

the antennal bristles (figs. 43, 44). Several varieties of *bitaeniorhynchus* have been described but Okinawan specimens seem to agree with the type form as described by Barraud (1934).

*Relation to Disease.*—This species does not appear to be an important vector of filariasis. Several workers have reported negative results in transmission experiments. Hu (1939) reported that out of 90 mosquitoes which fed on a heavily infected case of *W. bancrofti* only 33 were found with filarial larvae, and in only 1 specimen did these develop to the infective stage. Chagin and Kondratiev (1943) reported this species as one of the predominant vectors of Japanese "B" encephalitis in the Soviet Far East.

*NOTES ON CONTROL.*—During 1945 on Okinawa, in areas sprayed with DDT in oil by airplane, larvae of this species were reduced almost to the vanishing point.

**28. *Culex (Culex) sinensis* Theobald**—Figure 44.

*Culex gelidus sinensis* Theobald 1903. Monograph Culicidae 3:180 (type locality: Shaohyiling, China).

*Female.*—Length of wing 3.8 mm. Vertex with pale narrow curved and upright forked scales covering median area, flanked by some dark upright scales and a lateral patch of broad appressed pale scales; palpus with a few dull pale apical scales; proboscis with a median pale band occupying a little more than one-fifth of surface. Scutum with whitish and ochreous scales on anterior two-thirds, dark scaled behind this except for a few paler antescutellar scales; scutellum with dark scales at base of mid lobe, otherwise yellowish; apn and ppn with narrow ochreous scales; pleuron brown with patches of pale scales, no lower mesepimeral bristle; wing scales dark except for a row on hind margin of costa toward base; halter knob ochreous; femora and tibiae speckled with creamy scales, particularly on fore femur, hind surfaces of mid and hind femora mostly pale, hind femur with a knee spot; tarsi with a basal pale band on I and with narrow bands covering joints, weakest over last joint. Abdominal tergites with well defined apical and inconspicuous basal creamy bands.

*Male.*—Palpus longer than proboscis by more than length of last segment; long segment with two pale bands, last two segments with basal pale bands, last segment with apical two-fifths pale. Proboscis with pale band just beyond middle and covering about one-sixth of surface. Basal arm of paraproct moderate in size.

*Larva* (description based on 3 U. S. National Museum specimens collected in Assam from a rice field by D. E. Hardy).—Agreeing with description of *bitaeniorhynchus* (p. —) except as follows: Antenna with subapical bristles inserted nearly halfway from apex to tuft, shaft with a few inner basal spicules; clypeal spine stout and dark; head hairs *B* and *C* usually double, *d* small and double; mentum with about 23 teeth; second and fourth pentad hairs often triple or quadruple; siphon about 5.5 times its basal diameter, with about 9 triple or quadruple tufts more or less arranged in pairs, subapical dorsal pair of bristles about as long as subapical diameter of tube, pecten of 1 or 2 pale teeth near base of tube.

*Biology.*—Larvae occur in rice fields and large weedy pools (Barraud, 1934); and in streambed pools in hilly region (Feng, 1938). We reared one adult from a general collection of rice paddy larvae on Okinawa and found adults resting on damp rocks in the woods, collected them biting

horses at night, and took them biting man in houses at night. According to Feng (1938) they bite man freely during the early part of the night, and are frequently found in houses in the hilly regions of south China.

*Distribution*.—Widespread in the Oriental region; also occurring in Japan. In northwestern Okinawa we collected small numbers of adults at Nago, Chizuka, and Hentona.

*Systematics*.—The adult resembles that of *bitaeniorhynchus* but is darker, with a paler scutum and all dark wings. The larva is indistinguishable from that of *cornutus* Edwards, according to Barraud (1934). The arrangement of antennal bristles, two sizes of mentum teeth, few stout comb teeth and long dorsal siphon bristle are distinctive features.

*Relation to Disease*.—Yamada (1927) found that 15.4 per cent of the *W. bancrofti* larvae dissected from Japanese specimens 18 to 35 days after an infective blood meal, had completed their development. However, he classified the species as having a low suitability as an intermediate host.

## 29. *Culex (Culex) mimeticus* Noe—Figure 46.

*Culex mimeticus* Noe 1899. Bull. Soc. Ent. Ital. 31: 240 (type locality: Basilicata, Italy).

*Female*.—Length of wing 5.0 mm. Vertex with yellowish narrow curved and yellowish and dark brown upright forked scales in median area. a lateral spot of pale broad appressed scales; palpus white tipped; proboscis with a whitish band just beyond middle and occupying about one-fifth of surface. Thoracic integument dark brown; scutum with golden brown scales and some yellowish ones along margin and in front of scutellum; scutellum with yellowish narrow scales; apn and ppn with golden brown narrow curved scales; pleuron with patches of dull white scales; wing spotted with creamy scales. a spot at middle of costa extending onto subcosta. a spot at apical three-fourths of costa extending over base of veins 4.1 and 4.2. a spot at apex of vein 1 extending narrowly onto costa and vein 2.1. vein 3 broadly pale medially, vein 5.1 with subbasal spot. vein 5.2 often with a few pale apical scales and a pale fringe spot. basal half of vein 6 mostly pale; halter knob yellowish; femora pale posteriorly and ventrally for nearly whole length and with pale knee spots; fore and mid tibiae with pale posterior scaling for whole length; hind tibiae similar on middle three-fourths; tarsi with a band at base of I and bands over the following joints, weakest over IV-V. Abdominal tergites with pale basal bands.

*Male*.—Palpus longer than proboscis by more than last segment which is pale tipped. last two segments narrowly pale at base. long segment with two pale rings and a row of translucent outstanding scales beneath. increasing in length toward apex.

*Larva*.—Not known from Okinawa. Five specimens from Assam. Burma, and China in the U. S. National Museum agree fairly well with the description of Barraud (1934). These specimens exhibit the following characters: Antenna constricted and tufted just beyond middle, shaft with slender spicules. subapical bristles inserted well before tip and reaching about as far as apical one, shaft dark on apical two-fifths; clypeal spine stout, sharp and black; head hair *A* with about 8 branches, *B* double or triple, *C* triple or quadruple. *d* small, usually triple, and anterior to *B*; mentum with about 15 regular teeth. Shoulder hairs all long and single

except 7 which is double to quadruple. Comb of 25 to 40 fringed and apically spined teeth in a patch; first to fifth pentad hairs with about 5, 1, 8, 1 and 4 branches respectively; siphon about 6 to 7 times its basal diameter, with 4 or 5 pairs of tufts which are usually in an irregular ventral row of 8 to 10 tufts, basal tufts nearly twice diameter of tube at base, apical ones small and double or triple, a lateral hair tuft sometimes present; apical dorsal bristle stout and more than half as long as diameter of tube at point of insertion; pecten of about 17 slender teeth; anal segment with a complete sclerotized ring which is not spiculate posteriorly and which bears a double hair; gills about equal, pointed and nearly twice as long as anal ring; about 12 anal brushes in barred area; osc single, isc single or double.

*Biology*.—Larvae occur commonly in rice paddies. According to Feng (1938), they prefer fresh water pools or slowly running streams with green algae, but occasionally are found in clean water in artificial containers. Several workers on Okinawa reared the species from rice paddy collections. Adults are not known to feed on man.

*Distribution*.—According to Barraud (1934) it occurs in India, Ceylon, Burma, Cochin China, China, Mediterranean area, and Formosa. We have seen specimens from Japan. Okinawa records are from Nago.

*Systematics*.—*C. mimeticus* belongs to a group of closely related species which have banded proboscis, and wings spotted much as in *Anopheles*. In *mimeticus* the first pale costal spot extends only onto the subcosta. The mesosome of the only Okinawan male we have seen (fig. 46) appears to differ somewhat from that given by Barraud (1934).

### 30. *Culex (Culex) sitiens* Wiedemann—Figure 48.

(For description and further data, see p. 18.)

*Biology*. We collected a single female resting on vegetation in the woods. We have also studied larvae and adults sent to the National Museum by L. E. Roth. They were collected by J. Gillaspay from a brackish water pond on Ie Island in August, 1945.

*Records*.—Ie Island; Chizuka, Okinawa.

### 31. *Culex (Culex) tritaeniorhynchus* Giles—Figure 50.

*Culex tritaeniorhynchus* Giles 1901. Jour. Bombay Nat. Hist. Soc. 13: 606 (type locality: Travancore, India).

*Female*.—Length of wing 2.7 mm. Vertex with broad median area covered with narrow pale scales and dark brown upright forked ones; a lateral patch of pale broad appressed scales; palpus with a few apical pale scales; proboscis with a pale band just beyond middle and occupying about two-ninths of proboscis, some pale scales usually present on basal half of proboscis beneath, these sometimes forming an indistinct subbasal band. Scutal integument dark brown, covered with minute coppery brown scales, paler brown in prescutellar area; scutellum with pale brownish narrow scales; apn and ppn with scales as on scutum; pleuron with integument somewhat mottled, with patches of pale scales; wing dark scaled except for an indistinct area along hind margin of costa at base; halter knob with dull pale scales; legs mostly dark, paler on femora behind and narrowly at bases of tarsal segments, tarsal rings sometimes covering joints. Abdominal tergites with dull pale basal bands.

*Male*.—Palpus with 2 rings on long segment and rings at bases of last two segments, long segment with an inner ventral row of short hairlike scales. Lateral plate of mesosome with median process teeth somewhat curved but hardly if at all surpassing outer edge of ventral cornu (compare figs. 45, 50).

*Larva* (description based on 10 specimens collected on Okinawa from ground pools).—Antenna constricted and tufted at apical one-third, subapical bristles hardly surpassing apical long one, shaft dark at base and beyond tuft, numerous spicules present; clypeal spine strong and dark; head hair *A* with 5 to 7 branches, *B* double, *C* triple, *d* single to triple and placed slightly in front of *B*; mentum with 15 to 17 teeth. Shoulder hairs 1, 2, 3, 5 and 6 long and single, 4 single or double, 7 triple. Comb of 27 to 40 apically fringed teeth in a patch; first to fifth pentad hairs usually with 5, 1, 7, 1 and 6 branches respectively; siphon about 7 times its basal diameter, parallel-sided on apical one-half, 11 to 14 slender pecten teeth along basal one-fourth of tube, 5 triple or quadruple subventral hairs, the most basal about as long as basal diameter of tube, the most apical usually small, also a subapical dorsolateral tuft; anal segment with a complete sclerotized ring which is not posteriorly spiculate and which bears a small double to quadruple hair; gills equal, about as long as or shorter than anal ring, pointed; 12 anal brushes in barred area; osc single, isc double or triple.

*Biology*.—Larvae breed in a variety of situations. On Okinawa the habits appear to be more diversified than in any other mosquito. We found it in rice paddles, ground pools with or without vegetation, clean or polluted water, wells, artificial containers, stream margins, rock pools and in a deep spring hole in the side of a stream canyon. Adults rest in the woods on damp rocks and vegetation near the ground. They are persistent night biters and readily enter houses after dusk. We found them to be one of the two common species attacking horses. More than 250 specimens were taken from a horse trap at Hentona in one night and on several nights we collected 100 or more from a single horse. The species was not observed in April, was uncommon in May, abundant from June to August, reached a peak in the early part of September, and then dwindled in numbers.

*Distribution*.—According to Barraud (1934), the "range extends from the Mediterranean to China and Japan, and from West Africa and Egypt through the Oriental region, as far southwest as Celebes." It has also been reported from the Soviet Far East (Stickleberg, 1937). It was one of the commonest species on Okinawa after the first of May. Specimens were collected also on the Kerama Islands (L. Roth), Takabanare Island (R. Ingram) and Iheya Island (G. F. Augustson).

*Systematics*.—This species belongs to a complex of oriental forms which are often difficult to distinguish. Through most of its range, *tritaeniorhynchus* can be separated from *vishnui* by the dark tipped male palpus as well as the vertex scaling and mesosome structure. On Okinawa, however, *vishnui* has the male palpus practically all dark apically. The larvae of the two species differ radically, especially in the comb teeth (compare figs. 45, 50). The Philippine *summosus* Dyar has been cited as a synonym of both *vishnui* and *tritaeniorhynchus* (Bohart, 1945). It agrees closely with *tritaeniorhynchus* in larval and adult characters except that the mesosome resembles that of *vishnui*. In the Philippines there are other

closely related species which further confuse the picture. On Okinawa, *tritaeniorhynchus* larvae appear to be slightly atypical in having the gills short, often only half as long as the anal ring and rarely surpassing it in length.

*Relation to Disease.* Reports indicate that this species is of minor importance in the transmission of filariasis. Yamada (1927) dissected 328 filarial larvae of *W. bancrofti* from 20 specimens infected 11 to 60 days previously. Of the 328 only 27 had completed their growth, and Yamada concluded that the species had a low suitability as a vector. Hu (1935) reported that less than 4 per cent of his experimentally infected specimens carried *W. bancrofti* larvae to the infective stage. Hu (1940b) found infective larvae in only 2 out of 132 specimens fed on a moderately heavy case of *W. malayi*.

With respect to Japanese "B" encephalitis, Chagin and Kondratiev (1943) reported that *tritaeniorhynchus* was an important vector of this disease in the Soviet Far East. Japanese investigators have transmitted the disease experimentally with *tritaeniorhynchus* and have found infected adult mosquitoes in nature (Mitamura et al. 1939). Epidemiological evidence on Okinawa supports the theory that *tritaeniorhynchus* is a vector on that island (see discussion under *C. quinquefasciatus*).

### 32. *Culex (Culex) vishnui* Theobald—Figure 45.

*Culex vishnui* Theobald 1901. Monograph Culicidae I: 355 (female only) (type locality: Madras, India).

*Female.*—Agreeing with description of *tritaeniorhynchus* (p. 81) except as follows: Vertex with numerous pale upright forked scales toward middle, flanked by dark ones. Proboscis somewhat darker, band occupying about one-fifth. Scutal scales more shaggy, mixed coppery brown and brownish yellow.

*Male.* Palpus with two rings on long segment and rings at bases of last two segments, long segment with an inner ventral row of hairlike scales which are abundant and long toward apex of segment, last segment indistinctly pale at extreme apex in some specimens. Lateral plate of mesosome with median process teeth bent at right angles and surpassing outer edge of ventral cornu (compare figs. 45, 50).

*Larva* (description based on 3 specimens collected in Assam by D. E. Hardy.)—Antenna constricted and tufted at apical two-fifths, shaft with many spicules, darkened at base and beyond tuft, subapical bristles hardly surpassing apical long one; head hair *A* with about 10 branches, *B* double, *C* triple, *d* single; mentum with about 13 large teeth. Shoulder hairs 1 to 6 single, 7 triple. Comb of 5 to 7 large stout sharp teeth in an irregular row; first to fifth pentad hairs with about 5, 1, 6, 1 and 5 branches respectively; siphon about 5 times its basal diameter, parallel-sided along apical one-half; 10 to 12 pecten teeth of which distal few are very strong and curved; 1 lateral and 6 subventral tufts with 4 to 5 branches, longest tuft shorter than basal diameter of tube; anal segment with a complete sclerotized ring which is minutely spiculate posteriorly and which bears a very small multiple hair; gills pointed, equal, longer than anal ring; 12 short anal brushes in barred area; osc single, isc triple or quadruple.

*Biology.*—According to Barraud (1934), the larvae breed in "ground pools of almost every description, rice fields, salt marshes, etc." We did

not collect larvae of this species on Okinawa but the National Museum has larval material collected from a rice paddy on Iheya Island (north of Okinawa). We found adults in fair numbers resting in vegetation in the woods. It was not observed to feed.

*Distribution.*—Barraud (1934) records the species from "Mesopotamia to China and Japan, and throughout the Oriental region as far south-east as New Guinea". Ryukyu records are from Okinawa: Kochiya and Chizuka; and Iheya Island.

*Systematics.*—(See discussion under *tritaeniorhynchus*.)

*Relation to Disease.*—Very few experiments have been reported dealing with this species. The most significant is that of Brug (1938) who experimentally observed the complete development of *W. bancrofti* larvae and also found naturally infected specimens.

### 33. *Culex (Culex) quinquefasciatus* Say—Figure 51.

(For description and further notes, see p. 8.)

*Biology.*—Larvae on Okinawa, as elsewhere, are found in all types of artificial containers and in ground pools. Prolific sources of breeding are the small ponds or sumps which occur in many Okinawan dooryards. These are continually fed by rain and waste water and create ideal breeding places the year round. Several times these pools were observed with larvae so numerous that not all could remain at the surface at one time, or so it seemed. The larvae were commonly preyed upon by those of *vorax*. However, except sometimes in artificial containers, the *vorax* were so outnumbered that they had no appreciable effect on the *quinquefasciatus* population.

*Records.*—We found it the most abundant and widespread species on Okinawa and neighboring islands.

*Systematics.*—Considerable variation was observed in the larvae, particularly in siphon shape and siphon tufts, even among larvae from a single pool. Two of these variations are shown in figure 51.

*Relation to Disease.*—This is the most common and widespread mosquito on Okinawa, and the only domestic species biting at night. In July and August 1945 over 6,000 specimens were collected from native houses, some of which yielded as many as 500 blooded females. Filariasis caused by *W. bancrofti* is very common among natives of Okinawa (see introduction) and *C. quinquefasciatus* appears to be the primary vector. From April to June 1945 nearly 1,000 specimens collected from native habitations were dissected by W. G. Downs and the junior author. About 4 per cent were found to contain filarial larvae. Other workers during the same period reported as high as 27 per cent infectivity.

During the outbreak of Japanese "B" encephalitis on Okinawa, this species was abundant throughout the affected areas and could have been an important vector<sup>13</sup>. On the other hand, the limited nature of the outbreak might indicate that a less common or more zoophilic mosquito was responsible.

It seems probable that the ulcerations commonly observed on small children were caused by infected bites of mosquitoes, mostly *C. quinquefasciatus*.

<sup>13</sup> In the closely related *C. pipiens pallens*, Mitamura et al. (1939) demonstrated the passage of Japanese "B" encephalitis virus from infected adults through the egg and larval stages to the adult offspring.

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## EXPLANATION AND SOURCE OF FIGURES

[Figures not necessarily drawn to scale]

Figures 1-7, generalized mosquito structure; unexplained lettering: *C*, costa; *Sc*, subcosta; *af*, anterior fork cell; *pf*, posterior fork cell; *lh*, lateral hair of anal segment; *osc*, outer apical bristle; *isc*, inner apical bristle; *A*, *B*, *C*, *d*, *e*, and *f*, head hairs; fig. 5, left mesosome lobe dissected and shown in flattened view.

Figures 8-13, drawn from Okinawan specimens.

Figure 14, larval structures from a Bougainville, Solomons specimen; wing scales from an Okinawan specimen, dististyle from a Philippine specimen.

Figures 15-17, drawn from Okinawan specimens; figure 15, style in right ventral view and showing mesosome; figures 16 and 17, style in left ventral view with paraprocts and left side of ninth tergite; hind tarsus in outer view.

Figure 18, drawn from a Samoan specimen, pleural pattern including head, thorax and most of abdominal segments I and II.

Figure 19, drawn from Marshall Island material, comb teeth from a Namorik specimen and genitalia from an Ebon paratype.

Figure 20, comb teeth drawn from a Pulo Anna, Caroline specimen; basistyle lobes based on two specimens from Espiritu Santo, New Hebrides.

Figure 21, basistyle lobes drawn from Truk specimens; hind tarsals: *a-b*, Truk variations; *c-d*, Ulithi paratype variations.

Figure 22, drawn from Guam specimens.

Figure 23, drawn from Okinawan paratypes.

Figure 24, drawn from Rota paratypes; hind tarsus in outer view; dististyle in proportion to those of figures 25 and 26.

Figure 25, drawn from Guam specimens.

Figure 26, drawn from Saipan specimens.

Figures 27-28, drawn from Truk paratypes.

Figure 29, based on two specimens from Okinawa.

Figure 30, drawn from Samoan specimens, apical portion of claspette shown in ventral and lateral view.

Figures 31-32, drawn from Okinawan specimens, figure 32 from paratypes; hind tarsi of females and in outer view; claspette of *okinawanus* in ventral view and in dissected flattened view, showing attached basal lobe.

Figure 33, based on Guam specimens.

Figures 34-39, drawn from Okinawan specimens, adult structures of figure 39 drawn from type; subapical lobe of basistyle in figures 35 and 37 in left ventral view of dissected specimens; mesosome of figure 35 in dissected and flattened view (left lobe only); mesosome of figures 36-39 in ventral view, left side only except in figure 37; style of figure 38 with basal one-third omitted.

Figure 40, drawn from Truk paratypes; apex of style showing 2 common views of "birdlike" seta.

Figures 41-42, drawn from Okinawan specimens, figure 41 from paratypes; pleuron figures facing right and based on females; genitalic figures of left side in slightly flattened ventral view.

Figure 43, drawn from Okinawan specimens; mesosome (as in following figures) in dissected and flattened view of left lobe; lettering: *exp*, external process; *vc*, ventral cornu; *mp*, median process; *bp*, basal process.

Figure 44, larval structures based on Assam, India specimens; mesosome drawn from an Okinawan specimen.

Figure 45, larval structures based on specimens from Iheya (island north of Okinawa); mesosome from an Okinawan specimen.

Figure 46, larval structures drawn of a specimen from Nagasaki, Japan, mesosome of an Okinawan specimen.

Figure 47, based on paratypes from Rota; subapical lobe of basistyle from dissected style in left ventral view; paraproct and mesosome of left side in ventral view.

Figure 48, based on Guam material; subapical lobe of basistyle from dissected style in left ventral view.

Figure 49, larval structures taken from Guam specimens; mesosome from a Saipan paratype.

Figure 50, drawn from Okinawan specimens.

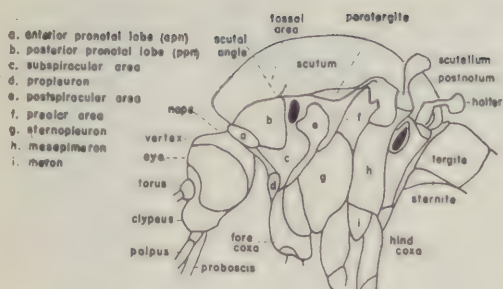
Figure 51, based on Okinawan material; siphon variations representing two larvae collected at the same time and place.

Figures 52-56, eggs deposited in the laboratory on Okinawa.

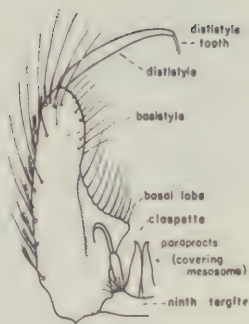
Figures 57-71, dorsal view of left pupal paddle and right pupal trumpet in slightly varying views from flattened pupal skins. Figures 57-61, 64, 66-67 and 70 drawn from Okinawan specimens; figures 62 and 71 drawn from Truk specimens; figures 63, 65 and 68 drawn from Guam specimens; figure 69 drawn from a Samar, Philippine specimen.

Figure 72, map of Guam. Stippled area indicates collecting records of *Aedes aegypti* from January through October 1945. Dededo and Santa Rita are villages located after reoccupation.

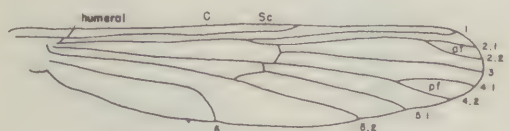
Figure 73, map of Okinawa and adjacent small islands. Specific localities labelled are those from which we have examined mosquitoes.



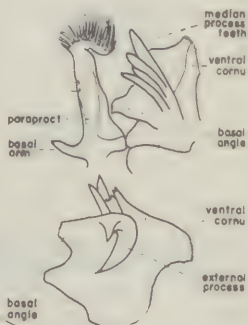
1. SIDE VIEW OF MOSQUITO HEAD, THORAX AND FIRST ABDOMINAL SEGMENT



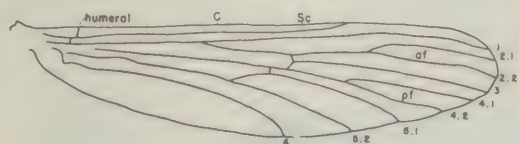
4. AEDES GENITALIA LEFT VENTRAL



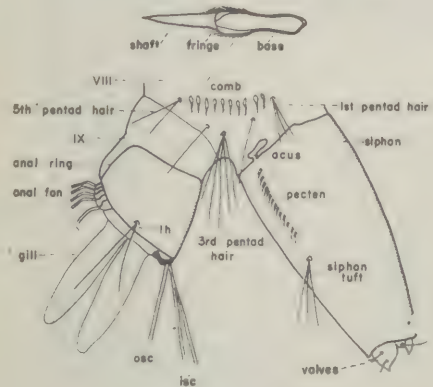
2. URANOTAENIA WING VENATION



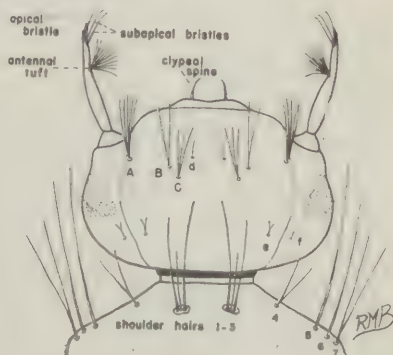
5. CULEX MESOSOME



3. CULEX (CULICOMYIA) WING VENATION



6. AEDES LARVA ABDOMINAL SEGMENTS VIII AND IX



7. CULEX LARVA HEAD AND PRONOTUM



wing



processes of  
ninth tergite  
of male

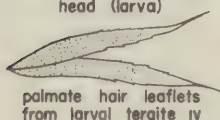
scutum



prothoracic submedian  
(shoulder) hairs of larva



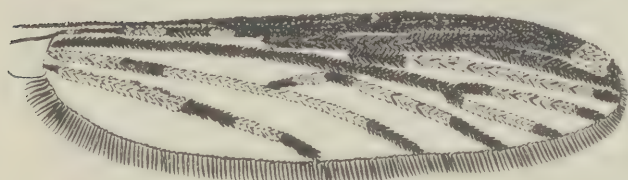
pecten (larva)



palmate hair leaflets  
from larval tergite IV

head (larva)

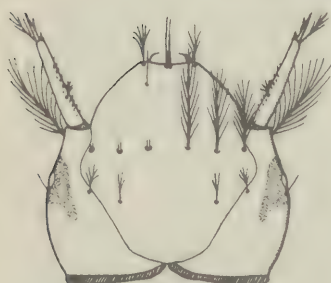
## 8. ANOPHELES (ANOPHELES) SINENSIS



wing



scutum



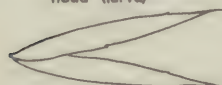
head (larva)



prothoracic submedian  
(shoulder) hairs of larva



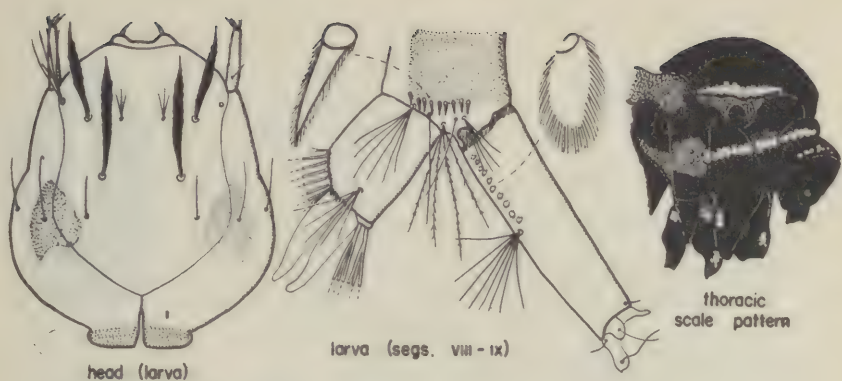
pecten (larva)



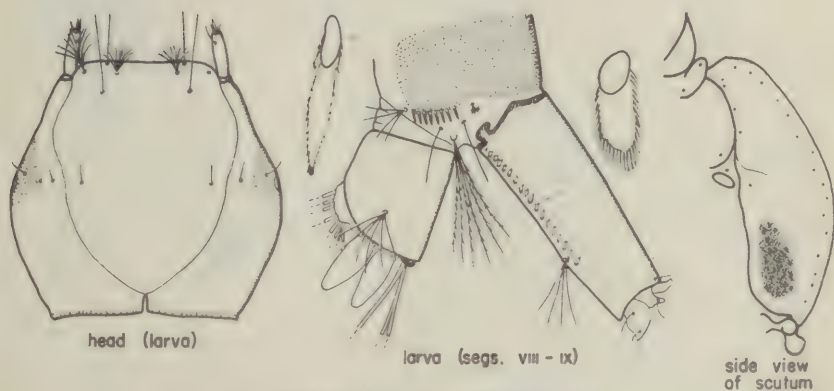
palmate hair leaflets  
from larval tergite IV

## 9. ANOPHELES (ANOPHELES) SAPEROI

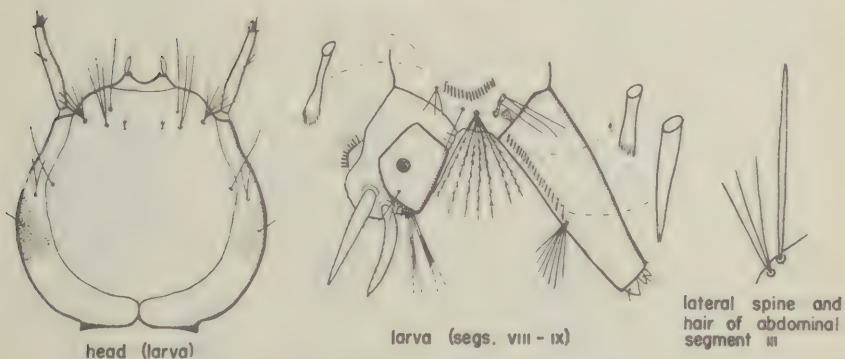
RMB



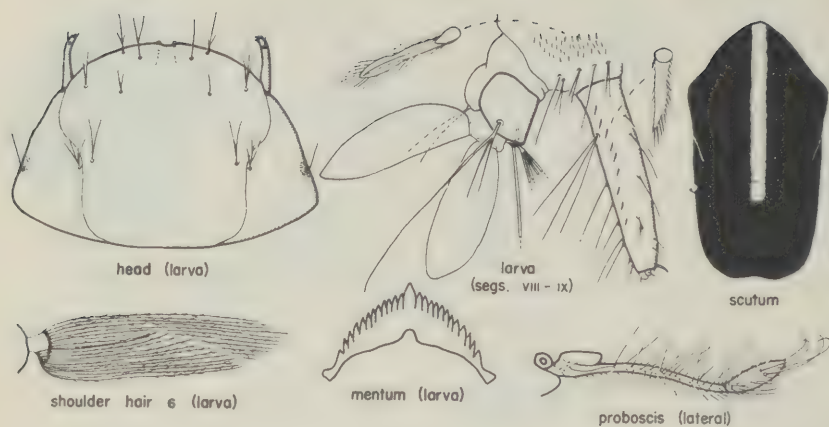
10. URANOTAENIA MACFARLANEI



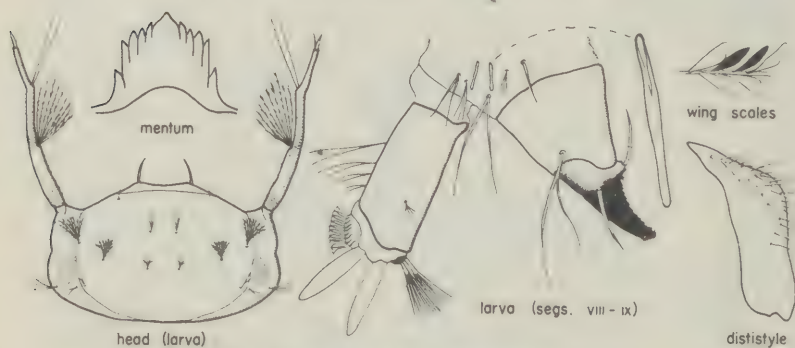
11. URANOTAENIA BIMACULATA



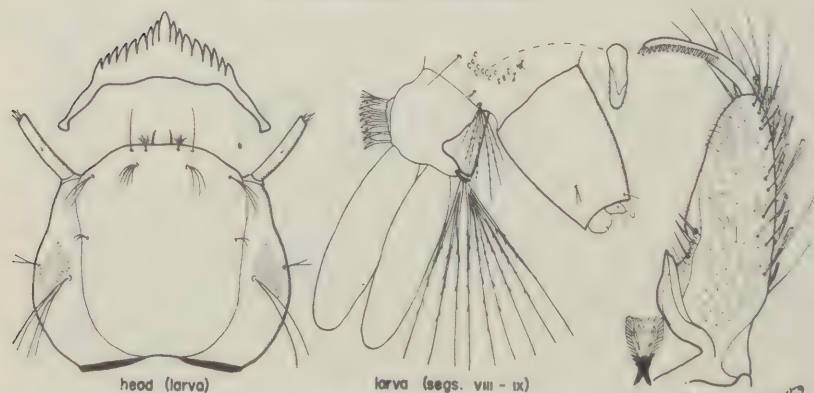
12. URANOTAENIA STONEI



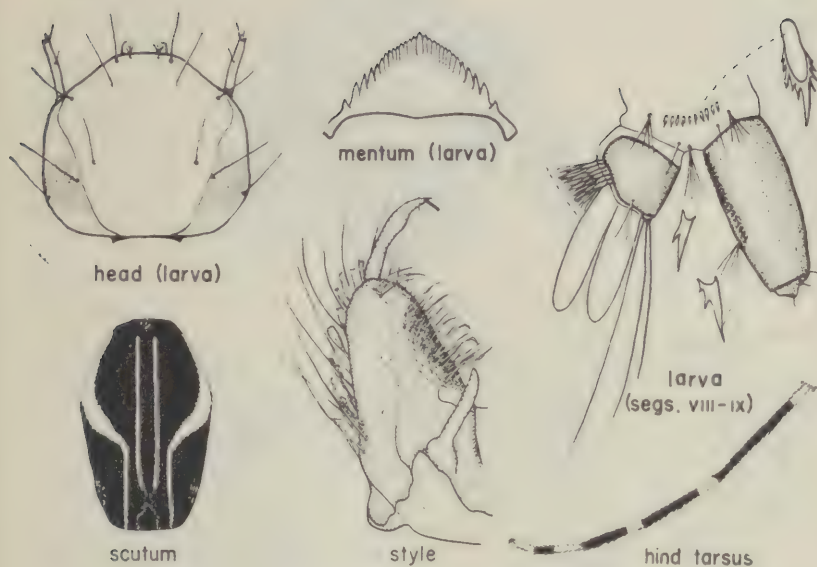
### 13. HARPAGOMYIA GENUROSTRIS



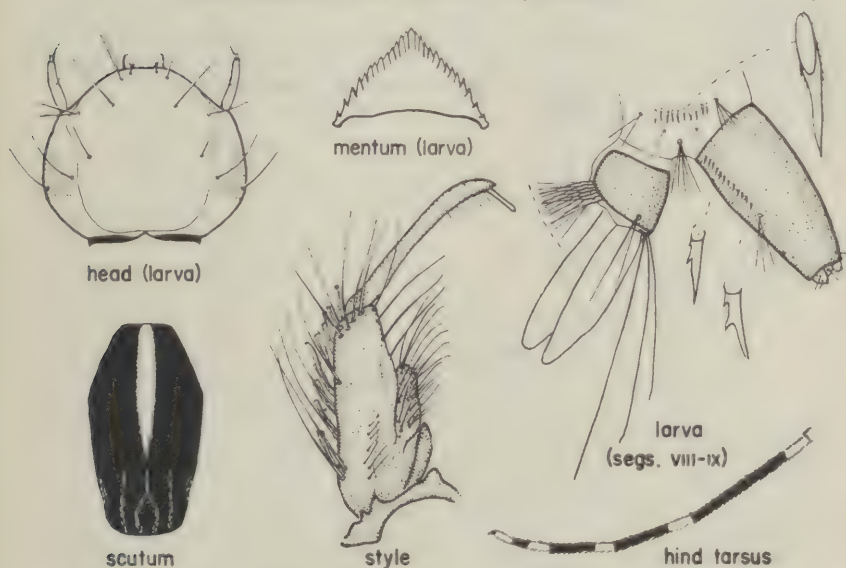
### 14. MANSONIA UNIFORMIS



### 15. ARMIGERES SUBALBATUS

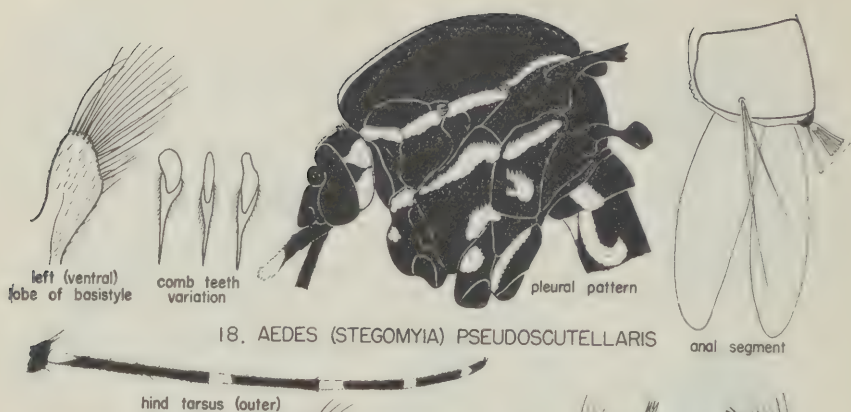


# 16. AEDES (STEGOMYIA) AEGYPTI

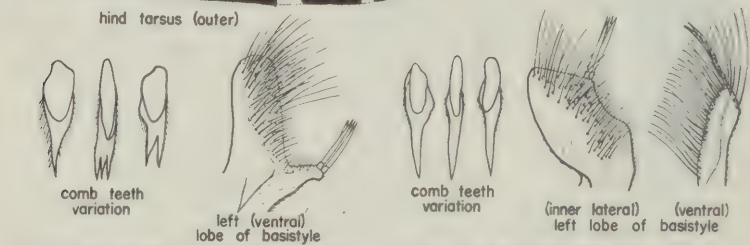


# 17. AEDES (STEGOMYIA) ALBOPICTUS

RMB

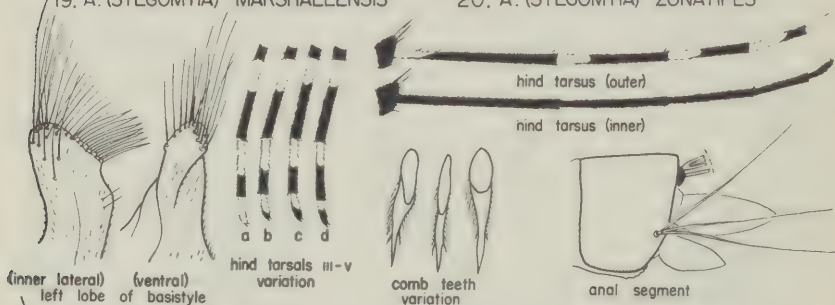


18. AEDES (STEGOMYIA) PSEUDOSCTELLARIS



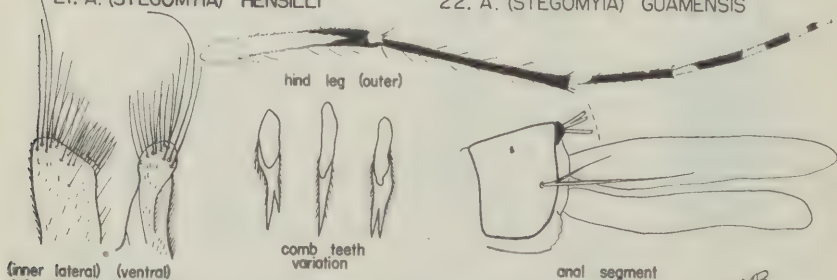
19. A. (STEGOMYIA) MARSHALLENSIS

20. A. (STEGOMYIA) ZONATIPES



21. A. (STEGOMYIA) HENSILLI

22. A. (STEGOMYIA) GUAMENSIS



23. AEDES (STEGOMYIA) RIVERSI

RMB



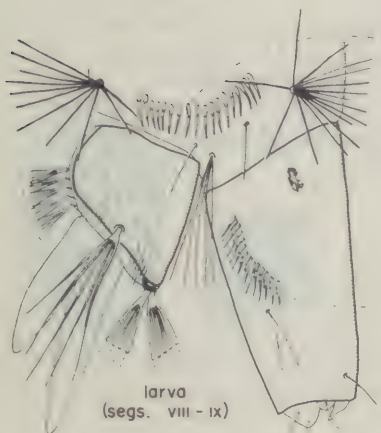
head (larva)



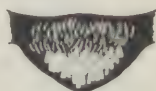
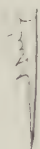
style



scutal pattern



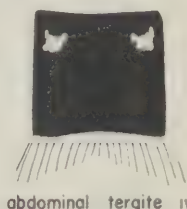
larva  
(segs. VIII - IX)



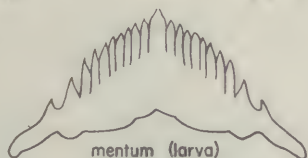
scutellum  
(mid lobe)



hind  
tarsus



abdominal tergite IV



mentum (larva)



dististyle

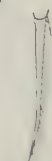
## 24. AEDES (STEGOMYIA) ROTANUS



dististyle



mentum (larva)



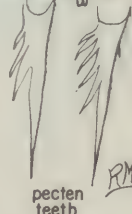
pecten  
tooth



dististyle



mentum (larva)

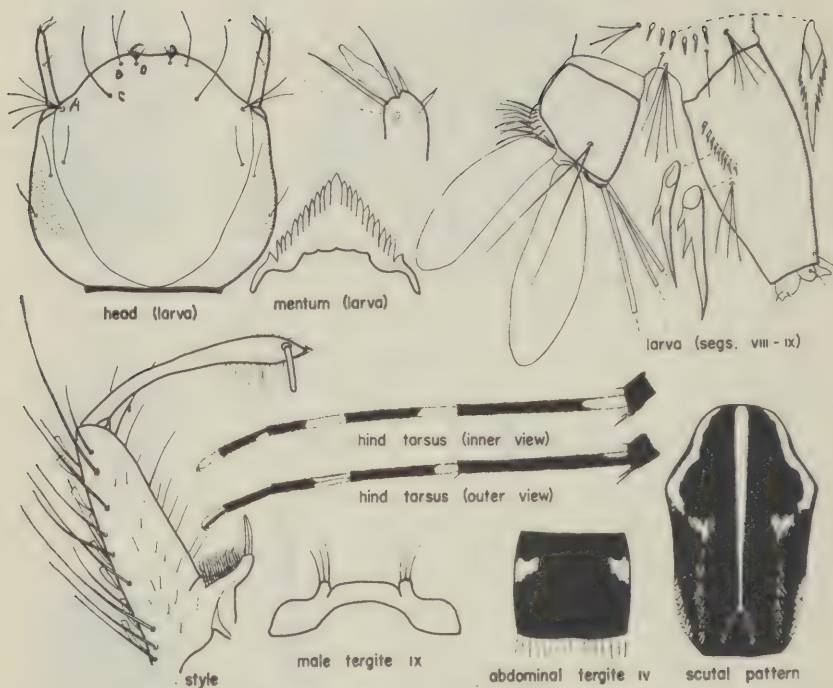


pecten  
teeth

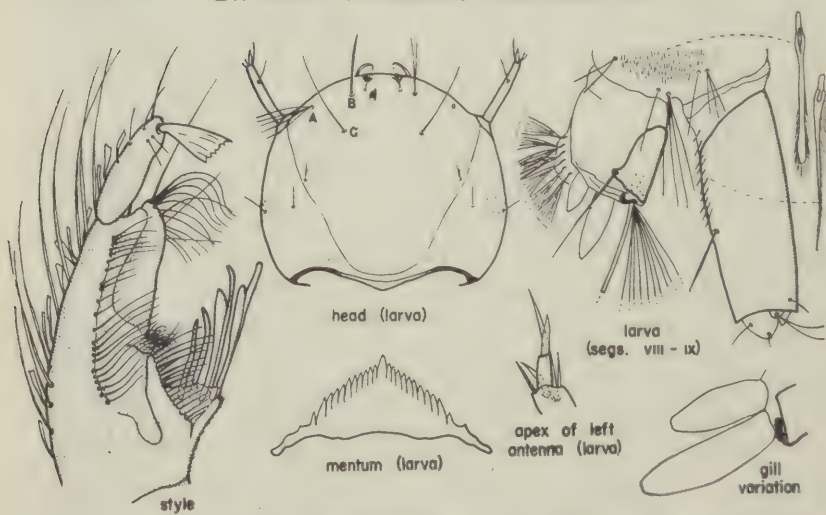
RMB

## 25. A. (STEGOMYIA) PANDANI

## 26. A. (STEGOMYIA) SAIPANENSIS

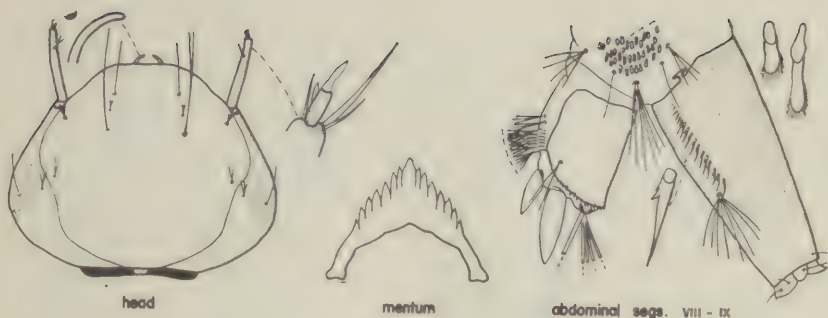


27. *Aedes (Stegomyia) scutscriptus*

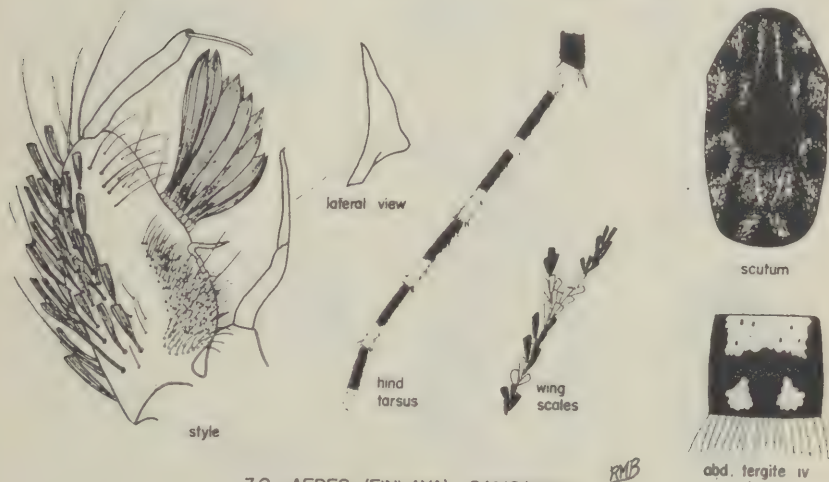
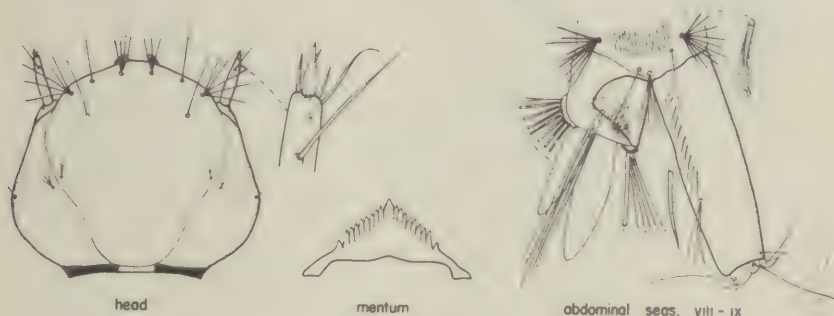


28. *Aedes (Skusea) lamelliferus*

RNB

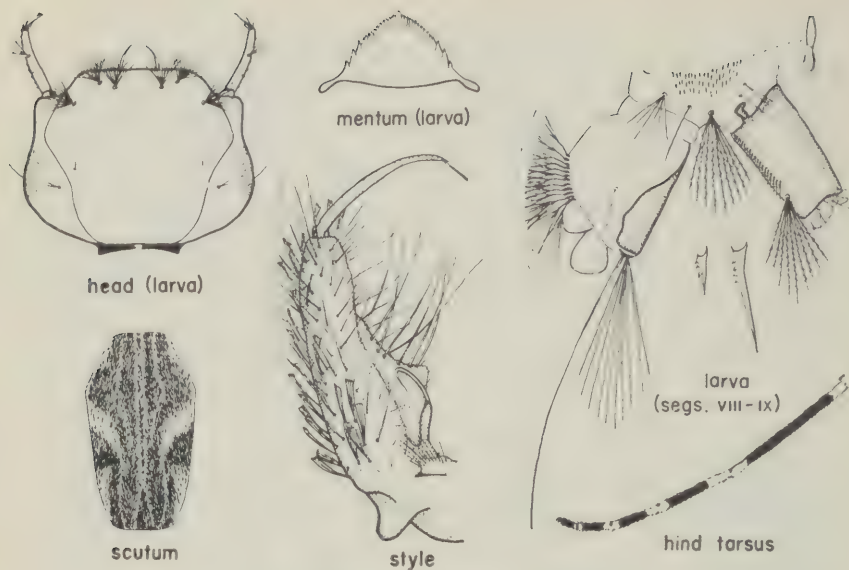


29. *Aedes* (FINLAYA) SP. IN GUBERNATORIS GROUP

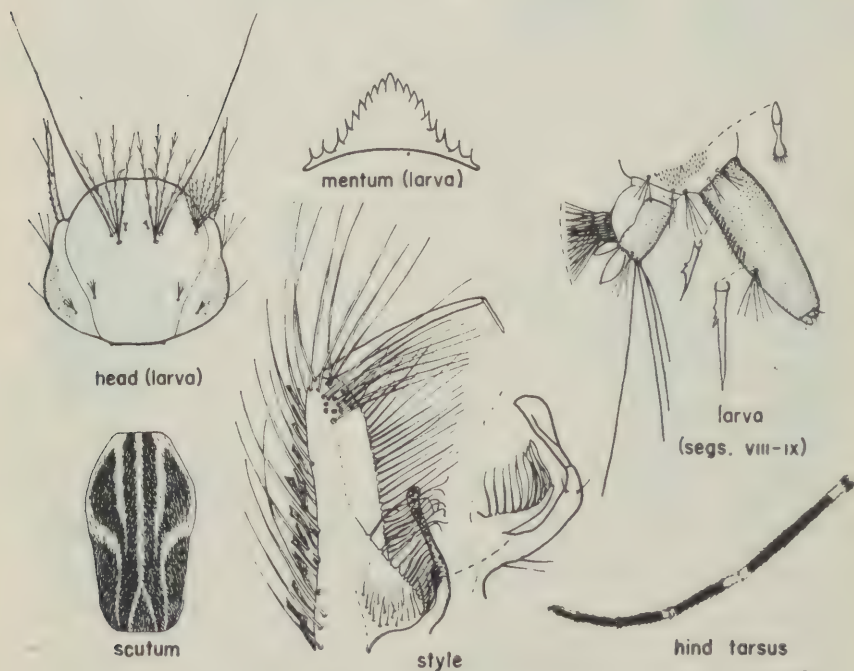


30. *Aedes* (FINLAYA) SAMOANUS

RMB

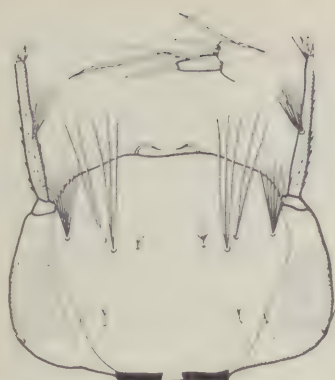


31. AEDES (FINLAYA) TOGOI

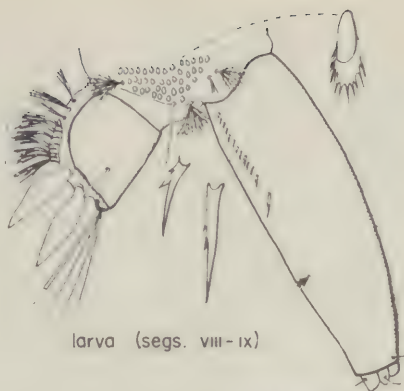


32. AEDES (FINLAYA) OKINAWANUS

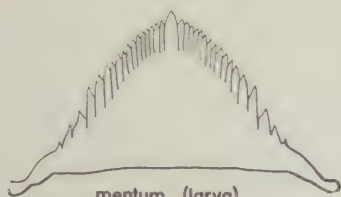
RMB



head (larva)



larva (segs. VIII-IX)

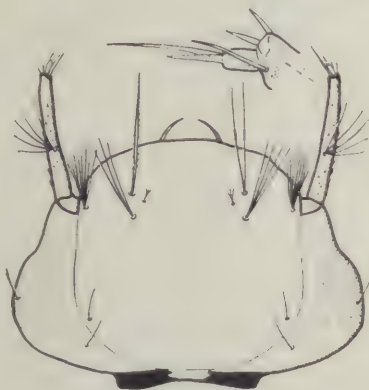


mentum (larva)

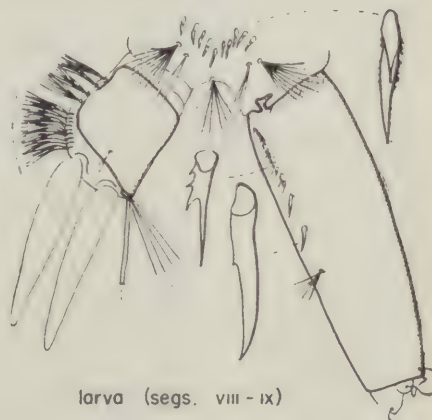


dististyle

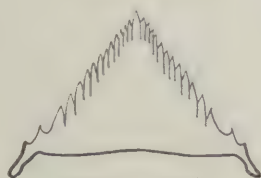
### 33. AEDES (AEDIMORPHUS) OAKLEYI



head (larva)



larva (segs. VIII-IX)

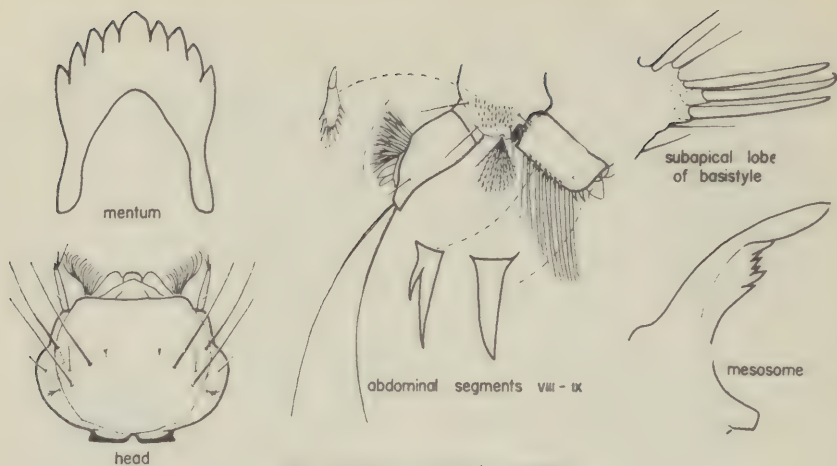


mentum (larva)

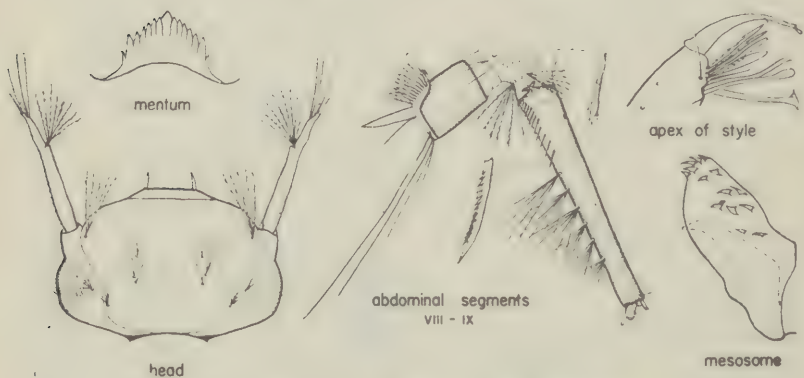


dististyle

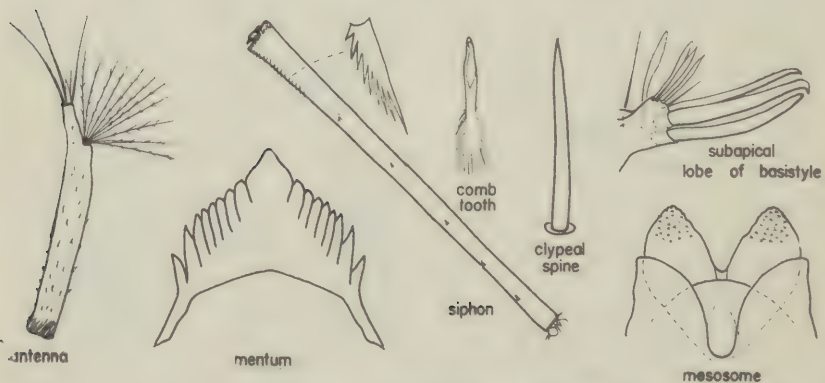
### 34. AEDES (AEDIMORPHUS) VEXANS NIPPONII



35. CULEX (LUTZIA) VORAX

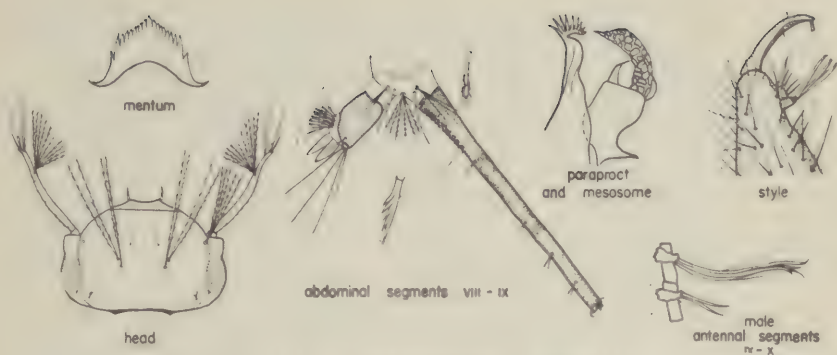


36. CULEX (NEOCULEX) HAYASHII

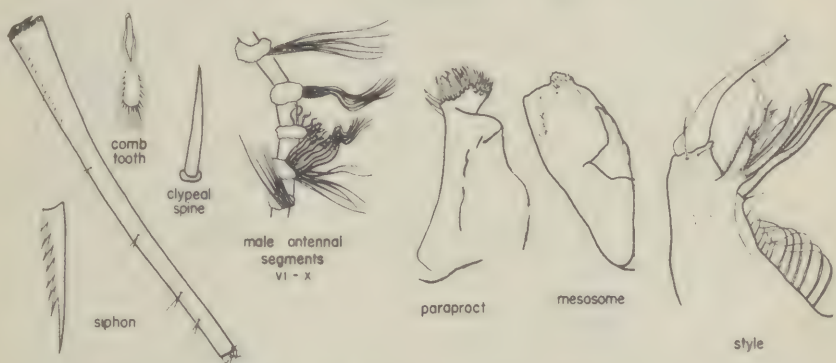


37. CULEX (NEOCULEX) BREVIPALPIS

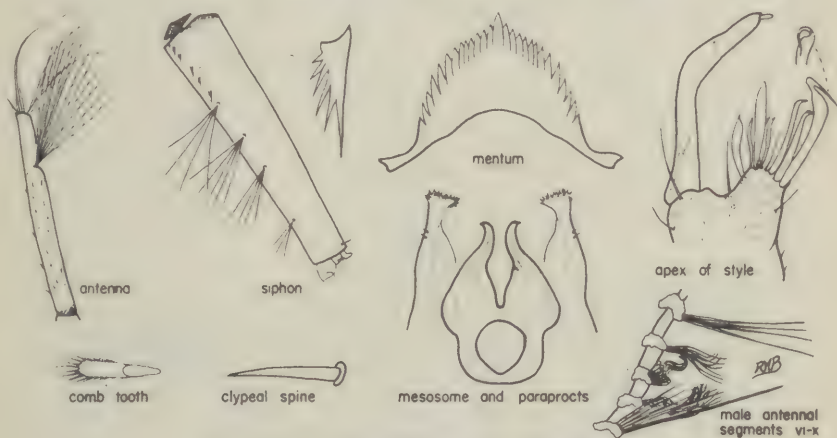
RMB



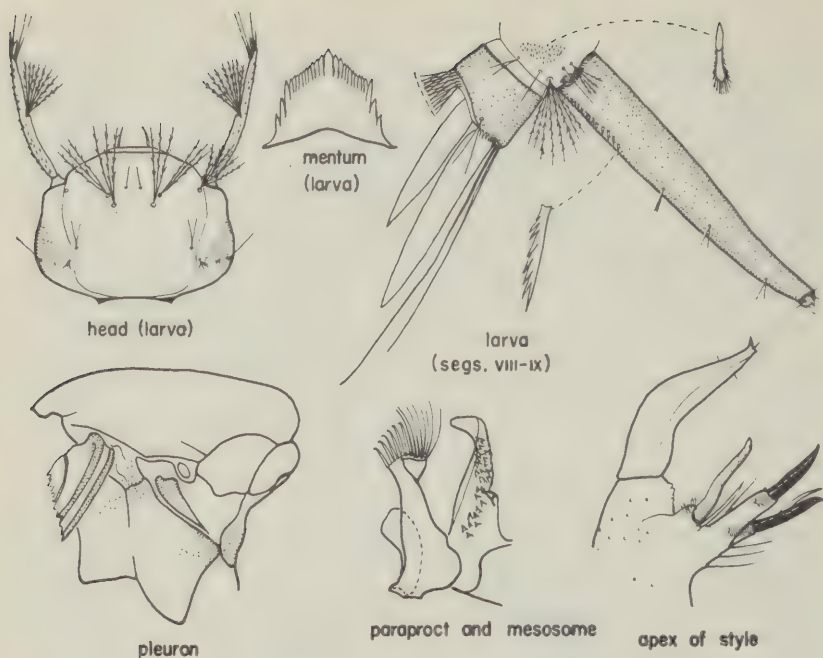
38. CULEX (LOPHOCERAOMYIA) INFANTULUS



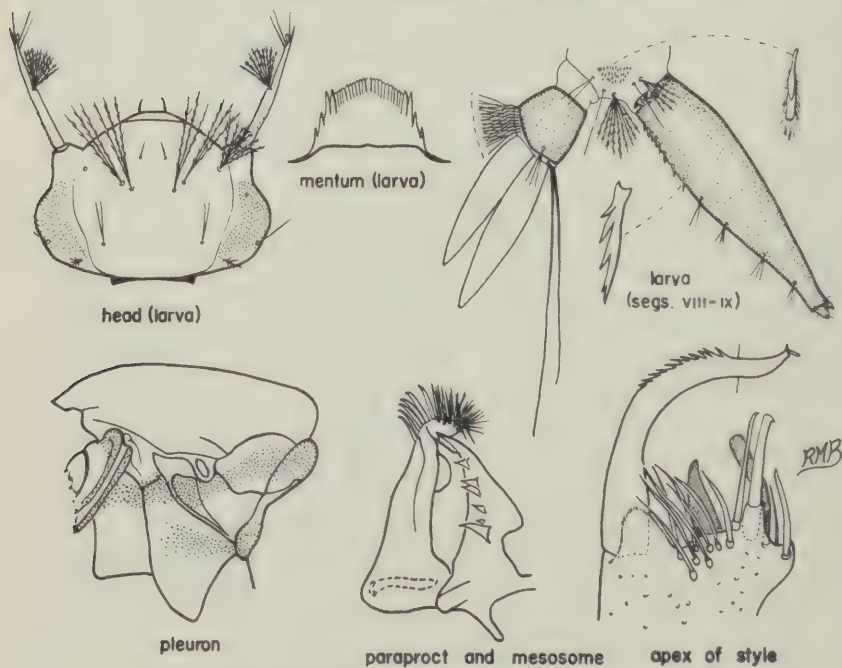
39. CULEX (LOPHOCERAOMYIA) TUBARIS



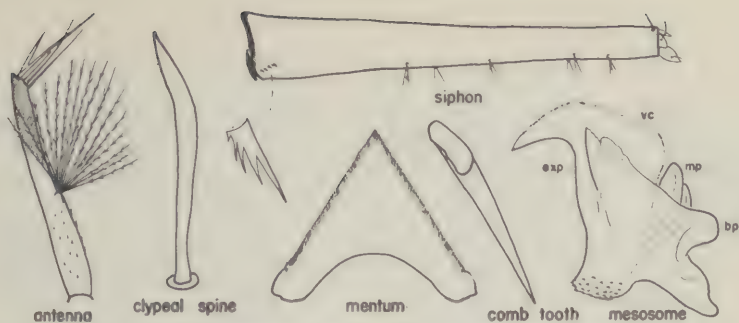
40. CULEX (LOPHOCERAOMYIA) CAROLINENSIS



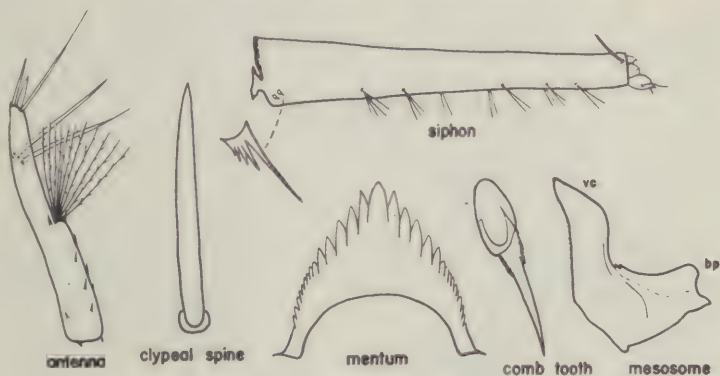
#### 41. CULEX (CULICIOMYIA) RYUKYENSIS



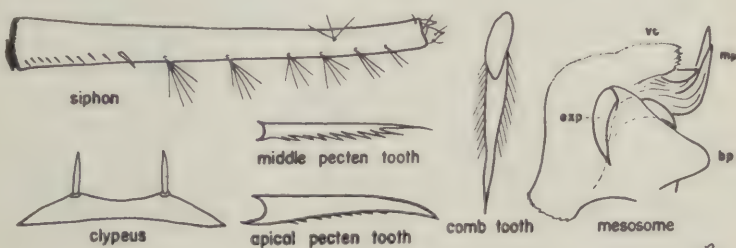
#### 42. CULEX (CULICIOMYIA) PALLIDOTHORAX



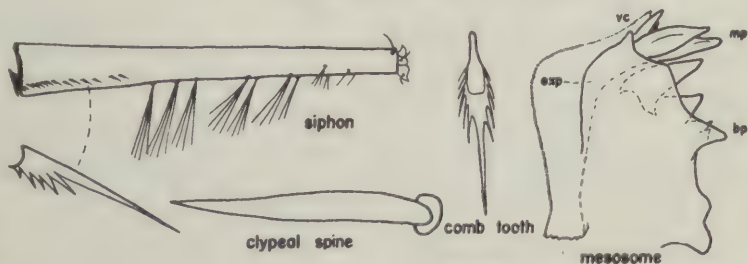
43. CULEX (CULEX) BITAENIORHYNCHUS



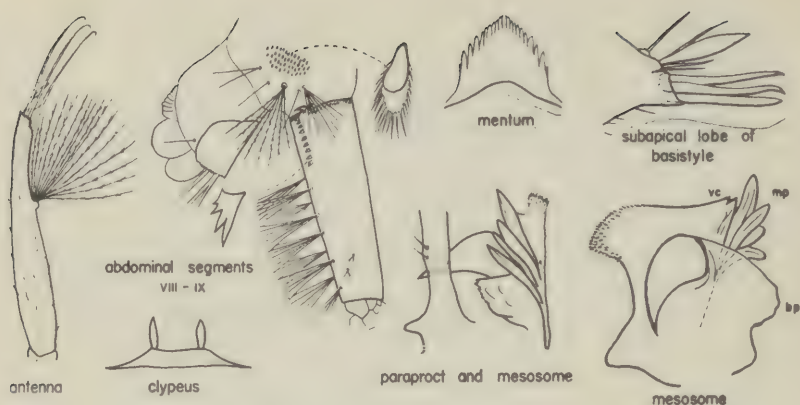
44. CULEX (CULEX) SINENSIS



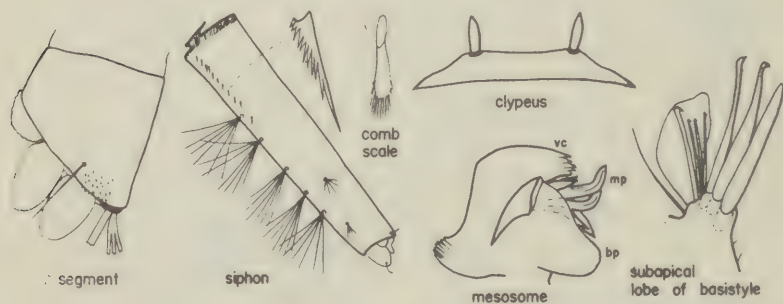
45. CULEX (CULEX) VISHNUI



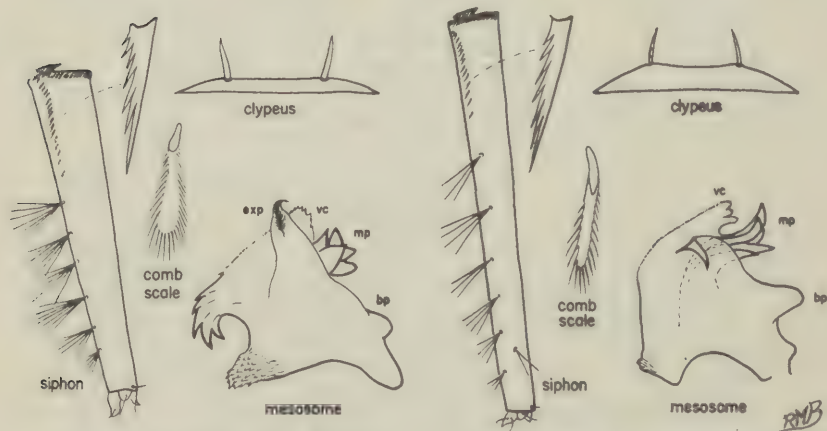
46. CULEX (CULEX) MIMETICUS



47. CULEX (CULEX) LITORALIS

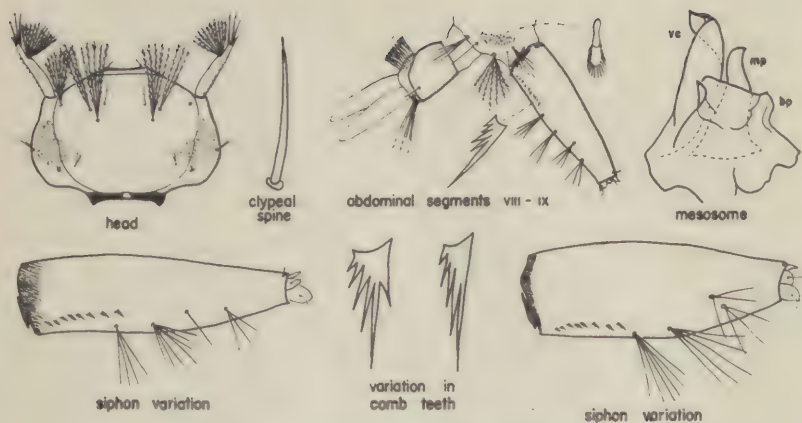


48. CULEX (CULEX) SITIENS

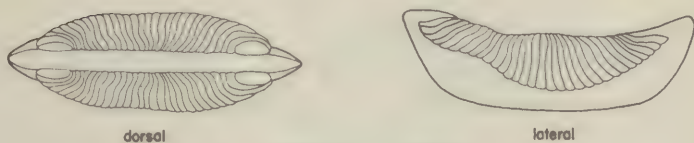


49. C. (CULEX) ANNULIROSTRIS MARIANAE

50. C. (CULEX) TRITAENIORHYNCHUS



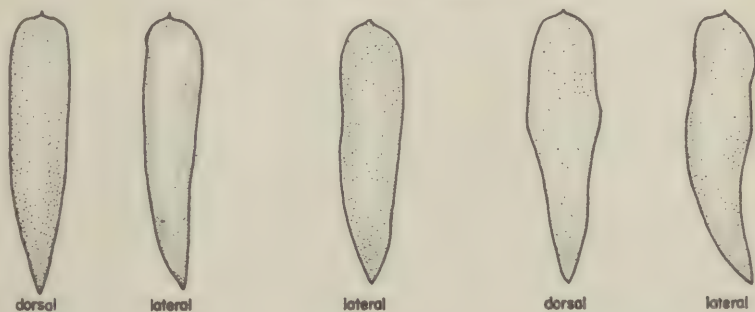
51. CULEX (CULEX) QUINQUEFASCIATUS



52. ANOPHELES SAPEROI



53. URANOTAENIA BIMACULATA



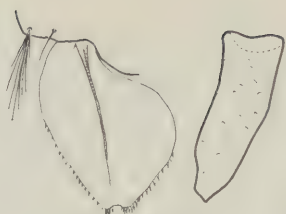
54. C. (LOPHO) INFANTULUS

55. C. (CULICIOMYIA) PALLIDOTHORAX

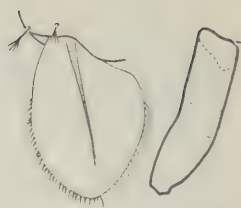
56. C. (NEOCULEX) HAYASHII



57. *Uranotaenia macfarlanei*



58. *Uranotaenia stonei*



59. *Uranotaenia bimaculata*



60. *Harpagomyia genurostris*



61. *Armigeres subalbatus*



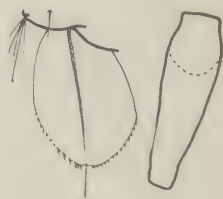
62. *Aedes lamelliferus*



63. *Aedes pandani*



64. *Aedes riversi*



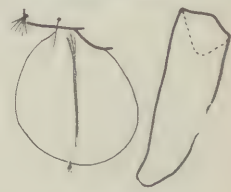
65. *Aedes aegypti*



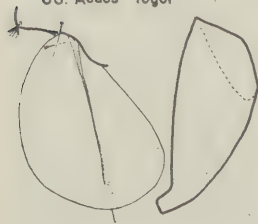
66. *Aedes togoi*



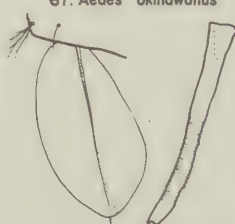
67. *Aedes okinawanus*



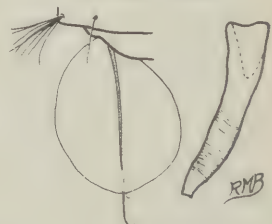
68. *Aedes oakleyi*



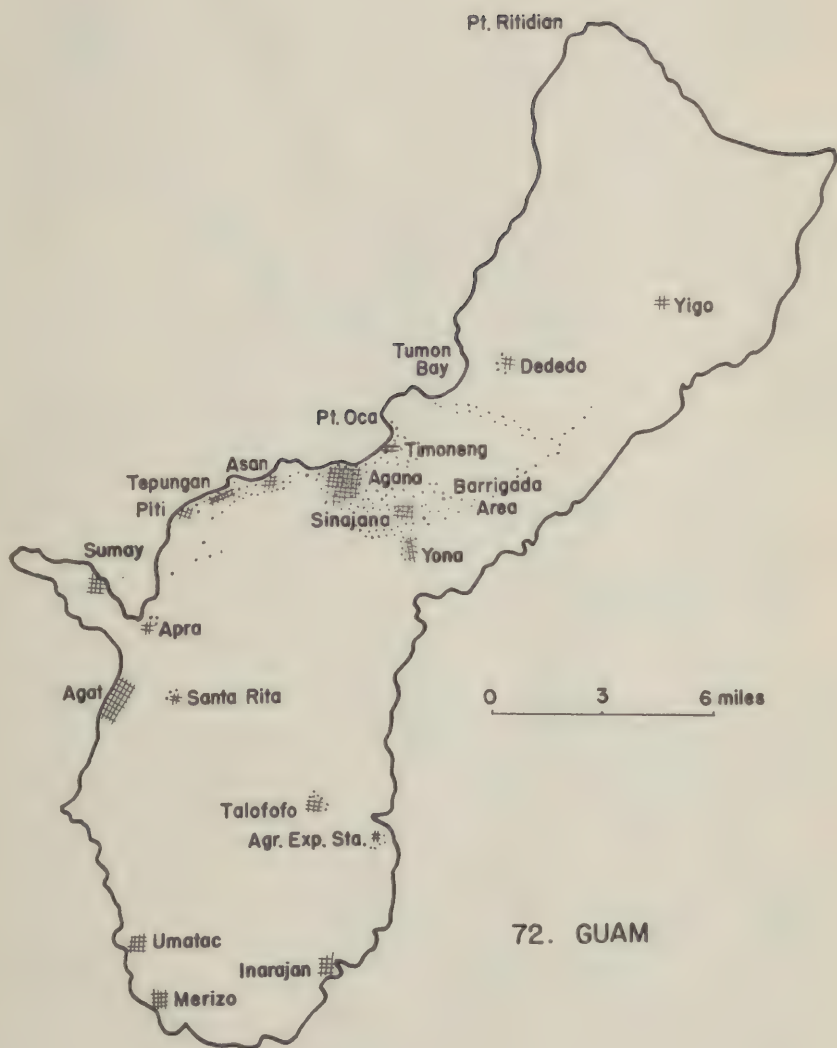
69. *Aedes vexans nocturnus*



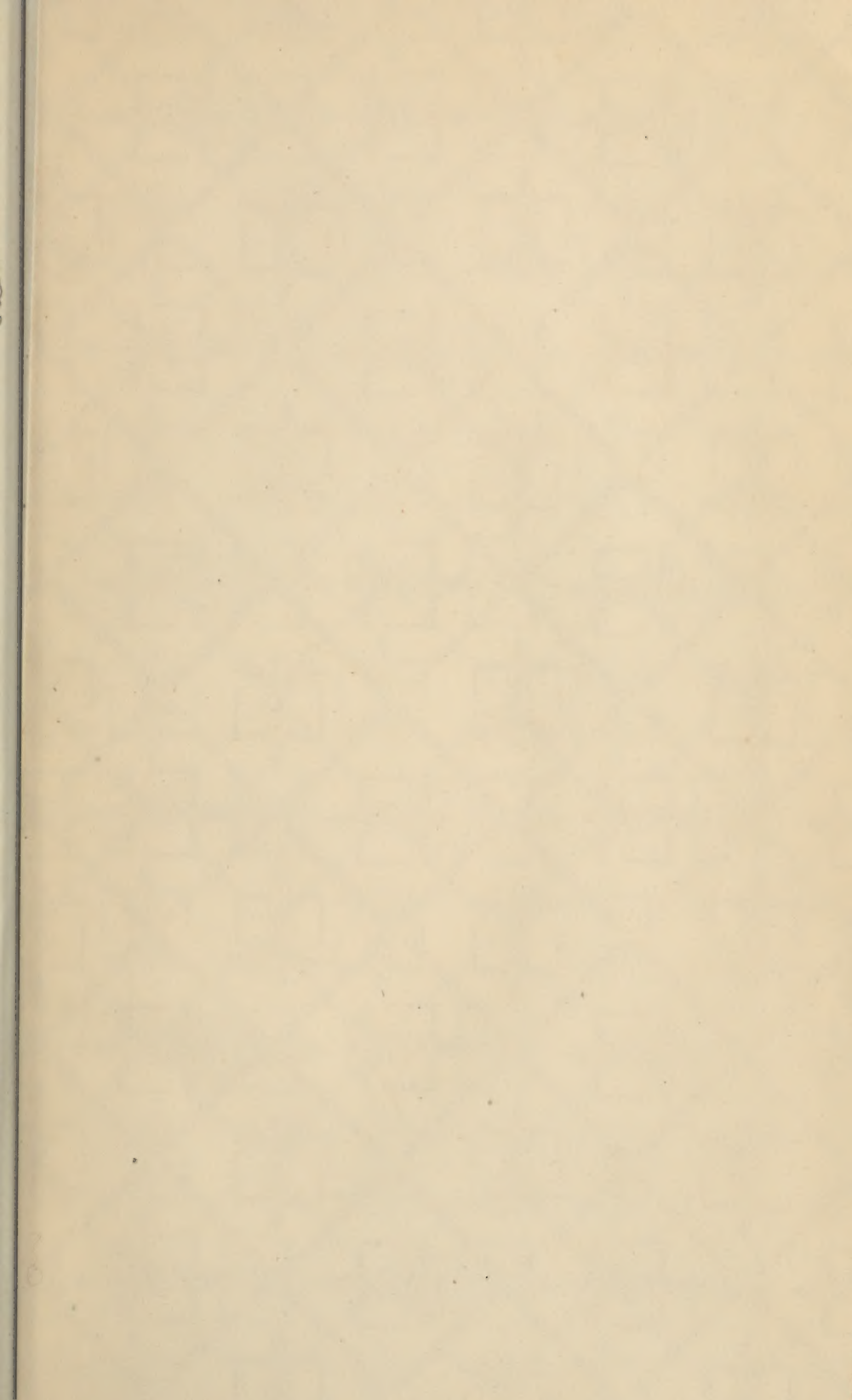
70. *Culex infantulus*

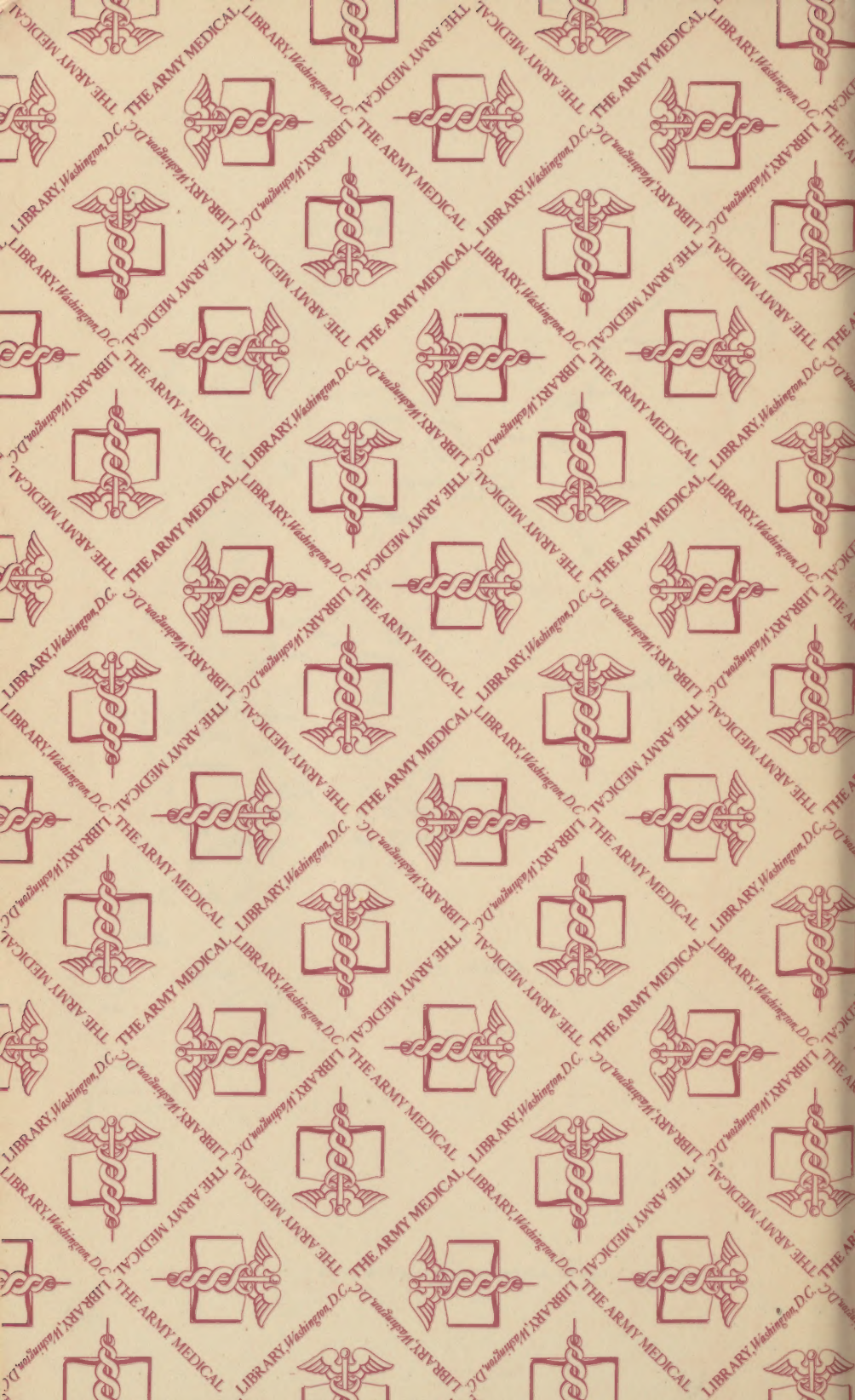


71. *Culex carolinensis*











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